Artificial Intelligence

Master of Science Degree

COMMENCING FALL 2021

Full Proposal

Submitted to:	Chancellor's Council on Graduate Studies Ohio Department of Higher Education
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Submitted by:	College of Arts and Sciences Kent State University, Kent, Ohio

KENT STATE UNIVERSITY

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A. Basic Characteristics of the Proposed Program

The program will be designated as "**Master of Science in Artificial Intelligence (AI).**" It will be housed within the Department of Computer Science at the Kent Campus of Kent State University, Kent, Ohio.

A.1 Purpose and Significance of the Program

Purpose

The program will prepare the much-needed workforce for a new wave of the emerging and knowledge-based industry for the 21st century.

Significance

The need for artificial intelligence has been growing at an annual rate of 30-40% in the USA[1]. Industry giants such as Amazon, Apple, Facebook, Google, IBM, Walmart, Lockheed Martin, Raytheon, Capgemini, Accenture, and Microsoft, automative companies such as Ford, Tesla, and Chrysler, banking companies such as Bank of America, JPMorgan Chase, and Goldman Sachs, insurance companies, cyber security companies, and many other corporations are spending 25-40 billions of dollars to develop AI infrastructure and industrial applications. According to a study,[1] the AI-based optimizations will boost the US economy by fourteen trillion dollars by the year 2035 with a 38% industrial growth.

It is estimated that there are 30,000 job-openings (see Appendix B, bottom graph) in AI-related areas. To meet this sustained industrial demand, the educational system has to graduate students with AI knowledge at a faster rate. The limited supply of AI-trained graduates is choking the AI-revolution in multiple sectors. The problem will become graver when 41% of slow adapters and 40% of contemplators join the revolution[2].

In January 2018, the US Congress enacted the H.R. 4829 Bill[3] to identify and promote industries that can benefit from artificial intelligence applications, improve both the AI labor force and the AI literacy, and enhance human life in various fields. Significant US research and industry funding are expected.

In recent years, many international and national universities have created MS programs in artificial intelligence (see Appendix D) to meet the growing demand. To our knowledge, among our peer group of universities in the State of Ohio, only the University of Cincinnati has created an MS program in artificial intelligence with a restricted AI-related curriculum. All other programs support AI-research with MS/PhD degrees within Computer Science.

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[1]Accenture report link: https://www. accenture.com/t20171005T065828Z w__/us-en/_acnmedia/Accenture/next-gen-5/insight-ai-industry-growth/pdf/Accenture-AI-Industry-Growth-Full-Report.pdfla=en?la=en).

[2]https://www.mckinsey.com/featured-insights/artificial-intelligence/applying-artificial-intelligence-for-social-good

[3]US Congress Bill link: https://www.congress.gov/bill/115th-congress/house-bill/4829/text

A.2 Definition of the Focus of the Program

Artificial Intelligence started as a subfield of computer science because both use computation to model the world. However, Artificial Intelligence is focused on solving real-world computationally prohibitive problems in realistic time by simulating human intelligence where computer algorithms fail to solve them in a reasonable time.

Artificial Intelligence simulates human intelligence by using a combination of programming; logical inferencing and fuzzy reasoning; planning; heuristics and metaheuristics to reduce the search-space; machine learning to improve efficiency through classification, clustering, neural networks and prediction techniques; computational perception and cognition; pattern matching; stochastic modeling and simulation; knowledge acquisition and representation; game-theoretic approaches; image analysis and understanding for object and scene recognition; probabilistic and statistical modeling and reasoning; probabilistic correlation analysis; intelligent haptics; natural language and intelligent visual interfaces; intelligent visualization to model; and intelligent automation and analytics.

Artificial Intelligence is significantly different from mechatronics. The latter system combines mechanical and electrical engineering to create automated mechanical movements. Also, mechatronics does not include the AI concepts described above, such as high-level computer programming, computer connectivity, intelligent visual and natural language interfaces, information and data security, intelligent visualization, intelligent analytics, pattern recognition, and algorithmics.

The proposed program will focus on three theme areas: *intelligent analytics*, *robotics*, and *smart communities and automation*. *Intelligent analytics* combines artificial intelligence techniques to recognize and optimize a process and derive non-intuitive patterns. The processes could be scientific, industrial, and centered on health workflow, decision making, or information retrieval. *Robotics* is the development of energy-optimized multi-sensor (including intelligent haptics) assisted by intelligent machines and their interfaces to support humans in hazardous situations, improve productivity, and provide entertainment, elderly-care, and healthcare. *Smart communities and automation* integrate automation techniques, intelligent sensor networks, and AI-systems to optimize and improve human quality of life. A few examples are smart homes and cities, intelligent transportation, intelligent visualization systems, computational health informatics, and the smart Internet connectivity of devices.

A.3 Rationale for the Degree Name

The program will prepare students for: 1) original doctoral-level and academic research and development in Artificial Intelligence by using the thesis pathway; 2) and industrial and societal applications of Artificial Intelligence by using the non-thesis pathway. The proposed degree will prepare students with in-depth knowledge of artificial intelligence by taking only AI-related courses and AI-related Capstone-projects or thesis. It is significantly different from the Master in Computer Science due to its focus on Artificial Intelligence compared to the breadth-requirement in the Master of Computer Science.

A.4 Duration of the Program

A student can be enrolled either full-time or part-time. Typical full-time students will complete this proposed two-year graduate-degree program with 30 credit hours of coursework (24 credits) and thesis/industrial-project (six credits) in two years.

The MS thesis pathway will emphasize a six-credit original research in the field of artificial intelligence and related fields, including interdisciplinary applications. The MS non-thesis pathway will emphasize: 1) optional three credit hours of an industrial graduate-level internship with three credit hours of an industrial-grade project applying artificial intelligence; or 2) six credit hours of an industrial-grade project applying artificial intelligence.

A.5 Proposed Initial Date for the Implementation of the Program

The proposed initial date for commencing the program is Fall 2021.

A.6 Admission Requirement and Admission Timing

The admission requirement for this program will be a Bachelor's degree in artificial intelligence, computer science, computer engineering, or a closely related area with the following undergraduate-level courses: 1) algorithms, 2) operating systems (recommended), 3) databases, 4) data structures, 5) probability and statistics, and 6) programming skills. The standard of the admission will be maintained by using the appropriate GRE (Graduate Record Examination) score administered by the Educational Testing Service and a GPA greater than 3.0 on the scale of 4.0. The admission standards are the same for computer science and artificial intelligence. The students will be admitted twice every year in Fall and Spring semesters.

A.7 Primary Target Audience of the Program

The Kent State University program targets the students (both full-time and part-time working adults) with a Bachelor's degree in computer science or related fields who want to specialize in the artificial intelligence and get employed in the knowledge-based industry or industries employing intelligent data analytics, automation, including robotics, and intelligent informatics and its applications such as health science, smart cities, smart homes, process discovery and optimization.

Although its aim is to train students with a general aim of contributing to societal needs, students who want to contribute to military applications of artificial intelligence will also benefit from the program. Military personnel and veterans with a Bachelor's degree in Computer Science or related fields will also be eligible to join the program.

A.8 Special Effort to Enroll and Retain Underrepresented Groups

(a) *Plan to ensure recruitment, retention, and graduation of groups underrepresented within the discipline*

Females and minority students, including African-Americans, Native Americans, Hispanics, Latinos, and multiracial individuals are underrepresented in computer science and need special encouragement.

The department has a healthy record of enrolling, retaining, and graduating undergraduate female students in computer science. The department has a student chapter of the ACM (Association of Computing Machinery) that organizes student activities. It has also started a women's chapter of the ACM within the department to encourage women participation. The department also supports and funds students to attend "Women in CS" conferences.

The MS program will be advertised to underrepresented undergraduate students within the Computer Science department, the university, and other colleges at the national level. The department will also advertise the program to various undergraduate groups, including PELL grant recipients, and will work in collaboration with the Office of Diversity to enhance the impact. The department will allocate advisors for underrepresented students to improve their retention.

New proposals will be written to federal agencies and state agencies to attract funding for underrepresented students under STEM initiatives. The university has many scholarships to encourage underrepresented students, including women, to STEM areas.

Moreover, the department has an industrial advisory board consisting of computer science faculty and local industrial partners. The concept will be extended to the Artificial Intelligence program. A mentorship program consisting of industrial professionals and faculty members will be established to scout and advise prospective underrepresented students.

(b) *General assessment of 1) institution and departmental profiles of total enrollment and graduate student enrollment of underrepresented groups within the discipline; and (2) comparison with national norms*

Table I summarizes the percentage of female and underrepresented students' enrollment and graduation for the last five years in the Department of Computer Science at Kent State University. Table II summarizes the current status of the enrollment and the number of underrepresented students within both the Department of Computer Science at Kent State University and Kent State University at large in the year 2018.

Table III summarizes the latest (year 2017) national CRA Taulbee Survey[4] (see Appendix C) of graduates in Computer Science and related fields (Computer Engineering and Informatics) from 181 of 281 PhD granting departments in the USA who responded to a national data collection. Since ethnicity cannot be established, nonresident aliens, and unrecorded data have been excluded. The underrepresented students only include documented African-Americans, Native Americans, Latinos, Hispanics, and multiracial individuals. The data is an approximation due to the nonuniformity of the number of reporting universities.

[4]CRA Taulbee Report: https://cra.org/wp-content/uploads/2018/05/2017-

The comparison with national norms shows that the percentage of female graduates in the Department of Computer Science at Kent State is much higher in the recent years (35-45% in the department vs. the 28% of the national norm). The department is doing well for underrepresented students at the Bachelor's level (7.1% compared to 4.1% nationally) and PhD level (two out of ten PhDs in 2018 compared to 3.2% nationally). The department also has a healthy enrollment of underrepresented students at the undergraduate level (11.9%). However, the department needs special effort to attract MS students in the underrepresented category (no underrepresented minority in the department in MS Computer Science program vs. 5.5 % nationally).

Table I. MS enrollment and graduation of female students in computer science at Kent State

	Enrollment Data						Graduation Data		
	Spring Semester			Fall Semester					
	Total	Females	Percent	Total	Females	Percent	Total	Females	Percent
2019	51	12	24%						
2018	58	17	29%	64	20	31%	49	22	45%
2017	110	38	35%	70	26	37%	107	37	35%
2016	184	68	37%	156	57	37%	108	34	31%
2015	177	54	31%	192	65	34%	82	18	22%
2014							53	16	30%

Table II. Underrepresented enrollment and graduation percentages in Fall 2018

Category	Enrollment Data (2018)						Graduation Data (2018)					
	Overall		Underrep.		Percent		Overall		Underrep.		Percent	
	CS	Total	CS	Subtotal	Overall	CS	CS	Total	CS	Total	CS	Total
UG	505	21,578	60	3, 373	15.6%	11.9%	84	5,589	6	725	7.1%	13.0%
Master	64	3,586	0	336	9.3%	0%	49	1,639	0	143	0%	8.5%
Doctoral	40	1,633	1	140	8.6%	2.5%	10	275	2	24	20%	8.7%

Table III. National norm summary of (CS + CE + Informatics) graduates in 2017 (original data in Appendix C)

Category	Females			Underrepresented students		
	Females	Total	Percent	Underrep.	Total	Percent
Bachelor	4, 747	17, 249	27.5%	718	17, 249	4.1 %
Master	3, 162	13, 037	26.1%	718	13, 037	5.5%
Doctoral	319	1834	17.4%	60	1, 834	3.2%

B. Institutional Planning for the Program Change

Although Kent State University does not have the named degree program, the Department of Computer Science has been offering undergraduate and graduate-level courses in artificial intelligence since 1988. The department has been graduating students with a Master in AI-related areas since 1985 and PhDs since the year 2001. Kent State University has active research-faculty, courses, and labs in artificial intelligence and related fields. It has graduated 40 MS thesis and 9 PhD dissertations with AI themes.

B.1 Physical Facilities, Equipment, and Staff Needed to Support the Program

Furthermore, the department has the required lab facilities and staff to absorb the projected enrollment of 40-50 students in the Master in AI program at the incremental growth rate of ten students per year. It would not need any further facilities, equipment, or additional staff for the proposed program.

(a) Physical facilities and equipment needed to support the program

Table IV shows the research labs that will absorb the thesis/project research work. The Artificial Intelligence Laboratory will also collaborate with the Center of Translation and Translation Technology (Professor Michael Carl's laboratory in the Department of Modern and Classical Languages) for projects related to natural language processing.

Table IV. Research Laboratories in the CS Department supporting the proposed program

	Laboratory	Director	Project activities to be absorbed
1.	Artificial Intelligence	Arvind Bansal	Social Robotics, human-humanoid interaction, intelligent computational health informatics, intelligent analytics, knowledge bases, biometrics and multimedia
2.	Computer Vision / Image Processing	Cheng Chang Lu	Biological image processing, medical image processing, computer vision
3.	Visualization	Ye Zhao	Urban planning, scientific visualization
4.	Perceptual Engg. and Media Net	Javed Khan	Perception and textual knowledge acquisition, cognition, eye-tracking, interactive online classroom
5.	Big Data and Science	Xiang Lian	Probabilistic data management
6.	Tele-Robotics	Jong-Hoon Kim	Human-robot interaction
7.	Digital Science	Jungyoon Kim	Smart devices and smart homes
8.	Emerging Technologies Laboratory	Gokarna Sharma	Internet of Things, sensor networks, and distributed robotics algorithms
9.	Networking	Hassan Peyravi	Wireless and mobile networks

The department has two general-purpose teaching labs, and two special-equipment educational labs, which are used for teaching lab-sections of many courses. Each lab has twenty-four desktops with recent technologies and a projector for presentations. These labs are sufficient for course-projects in intelligent analytics. One special-purposes lab is used for automation projects, robotics projects, and sensor networks projects. Another special-purpose lab is used for interactive projects and education.

The department also operates a "Data and Computing Center" with advanced storage, virtual machine, and computing resources. The networking group works with Ohio Research Network (OARNet) to integrate the department facilities with the national big-data resources utilizing extremely high bandwidth and industrial cloud-service providers (Amazon, IBM, Microsoft, etc.). This interconnectivity will assist in intelligent analytics experiments in big data.

(b) Staff needed to support the program

As described in Appendix F and Section F.1, there are 13 full-time PhD faculty members out of 18 graduate faculty members within the Department of Computer Science at Kent Campus who are already offering the required AI-related courses on a well-established rotational basis. All are active researchers and have supervised MS and/or PhD students in AI and AI-related fields. Hence, there is no need for any additional faculty member for the proposed program.

The CS labs are maintained exclusively by three research engineers who support the software and hardware needs. Additional system staff will not be required.

The program will be administered by the existing committee structure as detailed under Section F. The workload of the AI-coordinator, a senior faculty member selected from 13 associated faculty members, will be absorbed internally within the Department of Computer Science. Hence, there will be no additional administrative load for the projected growth of the program.

B.2 Evidence of the Existence of a Market for the Proposed Program

As described in Section A.1 (page 3), Artificial intelligence is the current digital frontier for the next twenty years, growing at an annual rate of 30-40% in the USA[1] (also see Appendix B).

According to a national survey,[5] 50% of the corporate executives are convinced of the success of AI-revolution. The growth is evident by a surge in investments by venture capitalists; the upswing of startup AI companies; the increase of jobs in AI since 2010 (see Appendix B); the enaction of the Congressional Bill HR 4289[3]; the US Congress' mandate of automation in health informatics; the increase in the use of intelligent robotics in smart transportation and community. According to a market survey company,[6] the intelligent personal robot market value will be $12.36 billion by the year 2023.

According to Monster.com (see Appendix B, bottom graph), there are around 30,000 jobs in the area of machine learning, deep learning, vision, natural language processing, algorithm development, intelligent analytics, and smart communities. In a similar vein, according to the New York Times[7], salaries of AI graduates can be high.

[5]Employment: https://www.accenture.com/t20180919T202227Z__w__/us-en/_acnmedia/PDF-86/Accenture-AI-Momentum-Final.pdf

[6]Survey link: https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-robots-market-120550497.html

[9]NY Times AI salary link: https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html

a. Realistic Enrollment Projections from an Estimated Program Demand

Based upon a 30% projected growth and 30,000 AI-related job listings, each of the 281 doctoral universities (CRA data) in the USA would have to produce around 100 graduates to meet the initial demand and around 40 students per year in order to keep up with the growth rate. Kent State has planned for the maximum enrollment of 40-50 students by the end of the fourth year.

b. Planning and Budgeting to Develop a Sustainable Quality Program

Kent State University regularly evaluates and enhances its programs to meet the market need. The university has been preparing the Department of Computer Science for the last five years by expanding the AI-related curriculum and the faculty strength to include automation and robotics, smart devices, intelligent analytics, smart communities, and AI in healthcare and education.

Per the fiscal impact statement (see Appendix G), the program will operate with an incremental growth of ten students per year and reach a stable increase of 40-50 students by the end of the fourth year without any additional burden to existing resources.

c. The need for the Degree Program, Including the Opportunities for Employment

Multiple national and international universities have started Masters in AI-related programs in recent years (see Appendix D). A survey of undergraduate students in the Department of Computer Science (Appendix B, Student Surveys) showed that 50% of students will consider a Master's degree in AI; 98% of 221 computer science undergraduate majors (juniors and seniors) supported an MS in AI, and 86% students were interested in taking graduate-level courses in AI.

The Bureau of Labor statistics[8] groups' artificial intelligence professionals are part of the class of "Computer and Information Research Scientist" with a median income of $114,520 and an employment growth of 19% that is much faster than that of other computer occupations (13%) and all other occupations (7%) for the decade 2016-2026. The local and regional need is evident through the job advertisements in AI-related areas as illustrated in Table V.

According to the job-advertisements, the employment need is vigorous in AI-architecture, model designers and validators, software development, consultancy, natural-language interfaces, machine learning, digital health, image analysis and vision, intelligence analytics, process control and automation, robotics (including tele-robotics), and intelligent simulation.

C. Statewide Alternatives

C.1 Programs Available at other Institutions and Differences

With the exception of the University of Cincinnati, universities in the State of Ohio **do not offer** any focused Master's degree in artificial intelligence (see Appendix E). The focus of the MS degree at the University of Cincinnati is fuzzy control systems (a subarea of automation)[9]. In contrast, the Kent State's AI-program supports *intelligent analytics, robotics, smart communities, and automation*.

[8]Bureau of Labor statistics link: https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm#tab-2

[9]https://webapps2.uc.edu/ecurriculum/DegreePrograms/Home/MajorMap/1961

Since the industry-wide demand for graduate students in AI is reasonably high to sustain growth in demand, we do not foresee any competition if other universities in Ohio jointly mitigate the need by starting a similar program in AI.

Table V. Regional distribution of companies advertising for artificial intelligence jobs in Ohio (based on job-advertisements in LinkedIn, Indeed.com, Ziprecruiter.com, glassdoor.com)

Region	Company names
Akron	The Goodyear Tire and Rubber Company
Beavercreek, Ohio	Riverside Research Institute; UST Inc.
Cincinnati, Ohio	Accenture; ALSAB Business Communications; ARI Simulations; Cincinnati Children's Hospital; Cold Jet; Dark Rhino; Deloitte; Etegent Technologies; Johnson and Johnson; Kao USA; Mercy Health; Procter and Gamble; SysMind
Cleveland, Ohio	Aconic; Big Cloud; Cannon Medical Research; Cleveland Clinic; Deloitte; IBM Watson Health; JumpStart; Moen; MRI Software; NASA Lewis; Philips; Rockwell Automation; Viasat
Columbus, Ohio	Amazon Web Services; Battelle; JP Morgan Chase; Nationwide; NCI Information Systems; Olive AI; Path Robotics; Root Insurance Company; Seamless AI; Sirius Computer Solutions; Sogeti; Synergetic Information Systems; The Xcel Masters; UpStart
Dayton, Ohio	AES Corporation; Altamira; Blackfinch Group; Booz Allen Hamilton; Centauri; DCS Corp; Leidos; Modern Technologies Solutions; Radiance Technologies; UES Inc.; Wright Patterson Airforce-base
Dublin, Ohio	Cardinal Health Company
Mason, Ohio	Makino; UST Global
Middletown, Ohio	Nirvana Enterprises
Patterson, Ohio	Applied Research Solutions; Riverside Research Institute
Westerville, Ohio	Softpath Systems; Sunrise Systems

C.2 Appropriateness of the Specific Locale for the Program

Kent State University is close to two major industrial demand centers of AI-related jobs: Akron and Cleveland, as shown in Table V. Cleveland is also a national center for healthcare maintenance and research due to the presence of Cleveland Clinic and University Hospitals. Kent State University has the necessary facilities and the department where the program will be housed. Kent State is a major public university that serves the demand in northeastern Ohio. Kent State is also a national university and one of the top four universities in the State of Ohio granting a PhD in Computer Science. Our students will serve the need of Ohio's population at both local and state levels.

C.3 Opportunities for inter-institutional collaboration

In the past, artificial intelligence researchers at Kent State have collaborated with peers from other major Ohio universities on major funded research. Various departments are also collaborating in organizing the "Women in Computing Conference." The creation of a focused graduate program will enhance more opportunities to collaborate on graduate AI research due to the availability of a larger pool of graduate students in each program.

D. Growth of the Program

D.1 Anticipated Growth

The program will be advertised nationally, internationally (through KSU's Office of Global Education and the department's global partnerships), and, regionally, via numerous direct outreach programs (such as the department's *CSforAll* workshop series for Northeast Ohio's school systems) to attract both domestic and foreign students. It is anticipated that the first-year enrollment of the MS students will be about 10 students. The enrollment will increase every year by ten additional students. The yearly enrollment will stabilize at 40-50 MS students by May 2025.

D.2 Growth Management

The required courses are being offered on a rotational schedule. With the same rotation schedule, every class will be able to absorb around ten additional students without any additional resource burden to the instructor, grader, educational lab, or system staff. The market demand will be continuously monitored based upon job advertisements and qualified students' applications to adjust the enrollment. We anticipate a capacity reevaluation after the 4th year.

D.3 Self-sufficiency of the Program

As evident from the Fiscal Impact Statement (Appendix G) and the discussion in Section F, there will be no negative fiscal impact of the proposed program on the departmental or university levels as the existing faculty, lab, and staff resources will be able to absorb the enrollment growth of the ten additional students during each of the first four years.

E. Curriculum and Instructional Design

E.1 Description of the Proposed Curriculum

The graduation requirement for the proposed program is to complete 30 credits of coursework (24 credits) and a culminating experience (six credits). The course-list is given in Table VI.

The proposed degree will have two pathways: 1) An MS thesis to prepare students for further doctoral-level and academic research; and 2) an MS non-thesis to prepare students for industrial research and a project development. The culminating experience for the MS thesis pathway will emphasize a six-credit original research thesis. The culminating experience for the MS

non-thesis pathway will be: 1) Three credit hours of an industrial-grade project and three credit hours of a graduate-level internship to prepare students for industrial research and development projects; or 2) six credit hours of industrial-grade project. The internship can be substituted for equivalent capstone-project credits.

Table VI. Description of the course structure in the proposed Master in AI program

Fundamental Courses (3 credit hours each, four lecture courses, Total: 12 credit)	
CS 54201 Artificial Intelligence	CS 64201 Adv. Artificial Intelligence
CS 54202 Principles of Machine Learning	CS 63005 Adv. Database Syst. Design
Other Foundational Courses (one out of three courses, 3 Credit hours)	
CS 53302 Algorithmic Robotics	CS 64301 Pattern Recognition Principle
CS 67302 Information Visualization	
Other Electives (3 credit hours each, three lecture courses, Total: 9 credit hours)	
CS 53301 Software Dev. For Robotics	CS 53303 Internet of Things
CS 53305 Advanced Digital Design	CS 53334 Human-Robot Interaction
CS 57201 Human Computer Interaction	CS 63015 Data Mining Techniques
CS 63016 Big Data Analytics	CS 63017 Big Data Management
CS 63018 Probabilistic Data Management	CS 63100 Computational Health Informatics
CS 63306 Embedded Computing	CS 64401 Image Processing and Vision
CS 64402 Multimedia System and Biometrics	CS 65203 Wireless and Mobile
CS 67301 Scientific Visualization	Remaining two foundational courses from CS 53302/CS67302/CS64301 not used above
Culminating experience (a 6-credit hour thesis OR a 3-credit hour non-thesis project)	
Non-thesis Option	**Thesis Option**
[CS 69192 Graduate Internship (3 credit) **and** CS 69099 Capstone Project (3 credit) **]** **OR** CS 69099 Capstone Project (6 credit)	CS 69199 Thesis I (6 credit)

As described in Table VI (also, see Appendix A), the coursework is divided into two parts: 1) core AI courses (five courses with 15 credit hours) and 2) elective courses (three courses with nine credit hours). Core courses are of two types: 1) fundamental courses; and 2) courses containing foundational content. Fundamental courses teach basic principles of Artificial Intelligence, machine learning, and large database and knowledge base design. There are four fundamental core courses: 1) Artificial Intelligence; 2) Principles of Machine Learning; 3) Advanced Artificial Intelligence, and 4) Advanced Database System Design. There are three other courses with foundational content: 1) Pattern Recognition Principles; 2) Information Visualization; 3) Algorithmic Robotics. Pattern Recognition Principles teaches probability and statistics, pattern analysis and unsupervised

statistical learning. Information visualization focuses on intelligent analysis and perceptual visualization of a large dataset for better perception. Algorithmic Robotics is concerned about the algorithmic aspects required in robotics and automation. Out of these three foundational courses, a student will take one course; the remaining courses will qualify as electives.

Five core courses are being taught annually. Out of the 18 elective courses, 17 are established courses and are taught regularly in a rotation schedule. A course on "Natural Language Processing" is under development.

A student can also take one advisor-approved thesis or a project-related elective course from a collaborating discipline such as psychology for cognition and learning, comprehension and knowledge acquisition, vision and perception; biological sciences for intelligent omics (genomics, proteomics, transcriptomics); classical and modern languages for natural language translation and understanding, and natural language interfaces; college of engineering and aeronautics for related engineering courses such as mechatronics and aerospace engineering; and college of communications and information for media analysis. As the program progresses, collaboration with other disciplines, based upon the growing applications of Artificial Intelligence, is envisaged.

E.2 Description of a Required Culminating Experience

The MS thesis option will have a six-credit hour research thesis focusing exclusively on the area of artificial intelligence or its application to collaborating fields. The thesis will be evaluated by a committee of three qualified graduate faculty members chosen from the related fields. Graduate-faculty members are active researchers. A thesis will contain both theoretical contributions and software development. The MS non-thesis option will have three credits dealing with a substantial AI-related problem-solving and industrial project-development skills and three credit hours of optional AI-related industrial internship. Internship credits can be substituted for equivalent capstone credits. The projects and thesis will have input from the industrial advisory board based upon their needs and their projection of future market needs. AI-related projects would be significantly different from the traditional CS-related projects.

The optional internship (three credit hours) and the capstone project (three credit hours) have been established recently for the non-thesis pathway. The thesis (six credit hours) for the thesis-pathway is already established.

F. Institutional Staffing, Faculty, and Student Support

F.1 Faculty Associated with the Program

There are 13 tenure-track and one NTT faculty members who are directly associated with the proposed program. All associated tenure-track faculty members are involved in teaching AI-related courses, are active researchers, and have the competence to direct a Master's thesis or a capstone project (see Table VII for their credentials). The AI-related courses taught by these faculty members are listed in Appendix F.

As a policy, a tenured/tenure-track professor teaches four courses per year (two courses per semester), and an NTT faculty member teaches eight courses per year (four courses per

semester). However, release-time is given to faculty members who are newly hired; have administrative duties; or have bought out time using their current research grants. Release situation varies every year.

Table VII. Credentials of the associated faculty members in the proposed program

Faculty	Rank	Degree (year)	Discipline (Univ.)	Teaching Experience	Additional Experience	Courses /year
1. Arvind Bansal	Full Prof.	PhD (1988)	CES (CWRU)	30 years	—	4
2. Michael Carl*	Full Prof.	PhD (2001)	CS (US)	10 years	Post-doc+ industry	2
3. Qiang Guan*	Asst. Prof.	PhD(2014)	CS(UNT)	3 years	Post doc.	3 (rel.)
4. Ruoming Jin	Full Prof.	PhD(2006)	CS (OSU)	10 years	—	2 (rel.)
5. Javed Khan	Full Prof. (Chair)	PhD (1995)	EECS (UH)	15 years	Post doc.	0 (rel.)
6. Jong-Hoon Kim*	Asst. Prof.	PhD(2011)	CS (LSU)	5 years	Post doc.	4
7. JungYoon Kim*	Asst. Prof.	PhD(2014)	CES (PSU)	3 years	Post doc.	2 (rel.)
8. KwangTaek Kim*	Asst. Prof.	PhD(2010)	CES (PU)	5 years	Post doc.	3 (rel.)
9. Xiang Lian*	Asst. Prof.	PhD (2009)	CS (HKUT)	9 years	Post doc.	4
10. Cheng Chang Lu	Full Prof.	PhD(1988)	EE (UTD)	30 years	—	2 (rel.)
11. Hassan Peyravi	Full Prof.	PhD (1985)	CS (UO)	30 years	Bell labs (3 years)	4
12. Augustus Samba	Full Prof. (NTT)	PhD(1983)	CS(UL)	15 years	Bell labs (14 years)	6 (rel.)
13. Gokarna Sharma*	Asst. Prof.	PhD(2014)	CS(LSU)	4 years	Post doc.	3 (rel.)
14. Ye Zhao	Full Prof.	PhD(2006)	CS (SU)	12 years	—	2 (rel.)

University name abbreviations:

CWRU – Case Western Reserve University, Cleveland, Ohio, USA
HKUT – Hongkong University of Science and Technology, Hongkong, China
LSU – Louisiana State University, Baton Rouge, Louisiana, USA
OSU – Ohio State University, Columbus, Ohio, USA
PU – Purdue University, West Lafayette, Indiana, USA
PSU – Pennsylvania State University, University Park, Pennsylvania, USA
SU – Stonybrook University, Long Island, New York, USA
UH – University of Hawaii at Manoa, Manoa, Hawaii, USA
UL – University of Liverpool, Liverpool, United Kingdom
UNT – University of North Texas, Denton, Texas, USA
UO – University of Oklahoma, Tulsa, Oklahoma, USA
US – Universität des Saarlandes, Saarbrücken, Germany
UTD – University of Texas at Dallas, Dallas, Texas, USA

Degree discipline abbreviations:

CS – Computer Science; CES – Computer Engg. and Science; EE – Electrical Engineering
CE – Computer Engineering; EECS – Electrical Engineering (Computer Science Track)

F.2 New Additional Hiring

There will be no new hiring in the proposed program. University has already hired seven (marked with asterisk in Table VII) out of the thirteen associated faculty members in the last five years according to its long-term planning.

F.3 Administrative Arrangement

The program will be administered by a subcommittee of the existing Graduate Studies Committee (GSC) within the Department of Computer Science. During the initial stabilization period, the subcommittee will be led by a senior associated faculty member (see Table VII) designated as *AI-coordinator*. The subcommittee will look after the policy developments, admissions' screenings, advising, the establishment of industrial relationships, and the promotion of the program and documentation creation. There will be no need for additional resources for administration.

F.4 Needed Financial Support for Staffing and Student Support

The involved faculty members have strong records of publications in refereed journals and conference proceedings, and research grants from national funding agencies. The department has sufficient support staff to run the labs and maintain equipment. Hence, there is no need for any additional funding for running the program. The department is also actively seeking national research and STEM funding. Also, the department is supported by substantial *Ohio First funding* to support domestic students. Hence, there is no need for additional financial support.

G. Academic Quality Assessment

The program is not an entry-level one. The program will go through the university's internal program assessment yearly to monitor its progress. It will also go through a departmental internal program assessment at the end of the second year to improve its overall administration and course structure. Moreover, the program will go through a yearly course structure improvement based upon the students' feedback and the industrial advisory board's recommendations. The program will also be evaluated by the external advisory board when the Department of Computer Science is evaluated every seven years.

Appendix A. Program Catalog Page

Description of Program:

The Master in Science degree prepares students with a focused educational and research environment to develop career paths through necessary learning and training with emerging Artificial Intelligence technologies and applications to intelligent analytics, smart homes and communities, and robotics and automation. Graduates will have technical knowledge and research and development skills necessary for applying artificial intelligence to industry, community, and military including sectors requiring intelligent pattern-analysis of big data such as retail, healthcare, biology, psychology, and intelligent human-machine interactions and interfaces.

Fully Offered At:
List all campuses/locations and methods (e.g., online, accelerated) at/for which a student can fully complete the program.

Kent Campus, Kent State University (traditional in-class with few hybrid courses)

Accreditation:
List specialized or professional accreditor for the program, if applicable.

Not Applicable

Admission Requirements:
Below are the minimum admission requirements for a graduate degree program. If the program has additional requirements or higher admission standards, list those.

- Bachelor's degree from an accredited college or university for unconditional admission
- Minimum 3.000 undergraduate GPA (on a 4.000 point scale) for unconditional admission
- Official transcript(s)
- Two letters of recommendation
- English language proficiency - all international students must provide proof of English language proficiency (unless they meet specific exceptions) by earning one of the following:
    - Minimum 525 TOEFL PBT score (paper-based version)
    - Minimum 71 TOEFL IBT score (Internet-based version)
    - Minimum 74 MELAB score
    - Minimum 6.0 IELTS score
    - Minimum 50 PTE score
    - Minimum 290 GRE score

For more information about graduate admissions, please visit the Graduate Studies website. For more information on international admission, visit the Office of Global Education website.

Program Learning Outcomes:
List the specific knowledge and skills directly related to the program's discipline that you expect students will have at the time of graduation to be successful in the field. The outcomes must be observable and measurable, rather than what students "know," "think," "understand, "appreciate," etc.

Graduates of this program will be able to perform one or more of the following tasks:

1. Combine intelligent analytics and automation, human-computer interaction and robotics techniques to optimize and automate, transportation, industrial process and/or healthcare processes.
2. Apply machine learning techniques on bigdata to predict, classify, datamine and explore patterns.
3. Apply intelligent visualization and Internet-based techniques for smart homes and communities.
4. Perform research, discovery, and integration by applying knowledge of AI theory and techniques.

Program Requirements:

Major Requirements		
Fundamental Courses (3 credit hrs. × Four mandatory core courses) - Subtotal: 12 credits		
Course	**Title**	**Credits**
CS 54201	Artificial Intelligence	3
CS 54202	Principles of Machine Learning	3
CS 63005	Adv. Database Syst. Design	3
CS 64201	Adv. Artificial Intelligence	3
Foundational Course (One out of three courses) Three credits		
CS 53302	Algorithmic Robotics[1]	3
CS 64301	Pattern Recognition Principle[1]	3
CS 67302	Information Visualization	3
Electives (3 credit hrs. × three lecture courses) – Subtotal: 9 credits		
CS 53301	Software Dev. For Robotics	3
CS 53303	Internet of Things	3
CS 53305	Advanced Digital Design	3
CS 53334	Human-Robot Interaction	3
CS 57201	Human Computer Interaction	3
CS 63015	Data Mining Techniques	3
CS 63016	Big Data Analytics	3
CS 63017	Big Data Management	3
CS 63018	Probabilistic Data Management	3
CS 63100	Computational Health Informatics	3
CS 63306	Embedded Computing	3
CS 64401	Image Processing and Vision	3
CS 64402	Multimedia System and Biometrics	3
CS 65203	Wireless and Mobile Communication	3
CS 67301	Scientific Visualization	3
Culminating Experience (a six-credit hour thesis) for Thesis Pathway OR [(a 3-credit hour Capstone Project + 3 credit optional internship) OR 6 credit hours of Capstone Projects] for Non-thesis Pathway		
CS 69099	Capstone Project (non-thesis pathway)	3 or 6
CS 69192	Graduate Internship (optional, non-thesis pathway)	3
CS 69199	Thesis I (thesis pathway)	6
	Minimum Total Credit Hours:	30

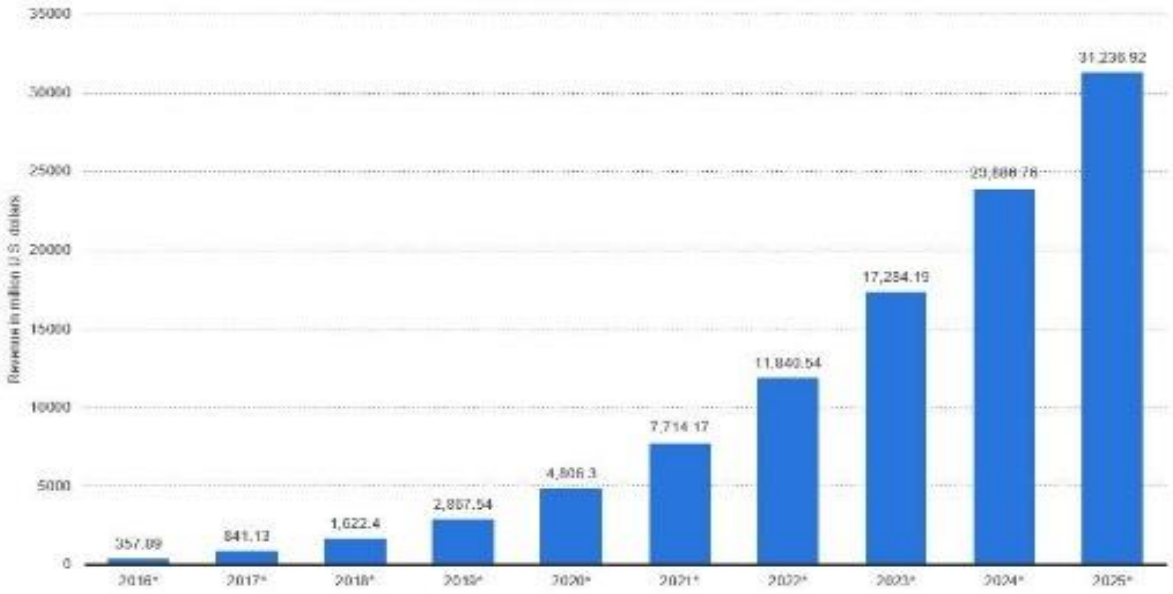
Graduation Requirements:
List additional requirements: (e.g., passage of specific exam) if applicable.

No additional requirements

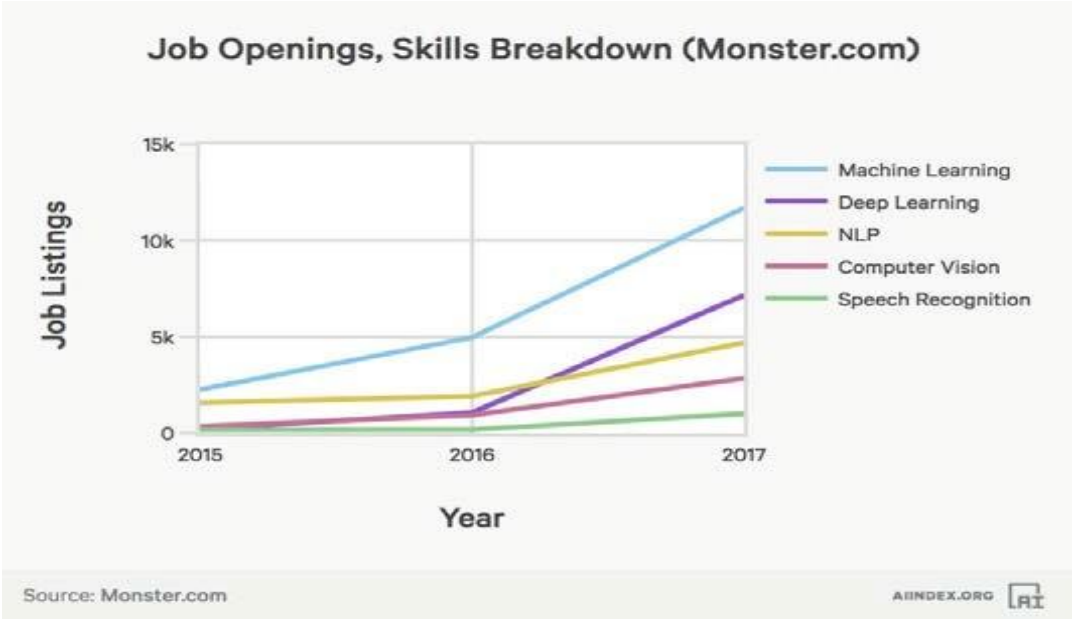
APPENDIX B. Market Analysis and Student Surveys

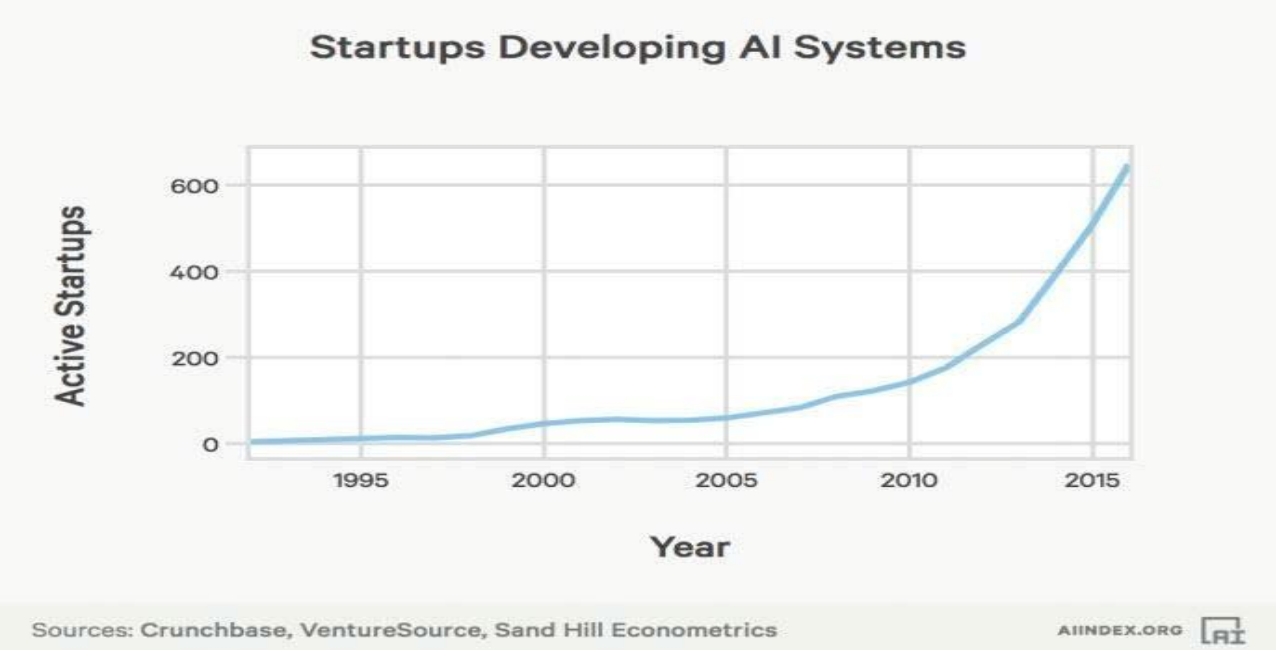
Enterprise artificial intelligence market revenue worldwide 2016-2025

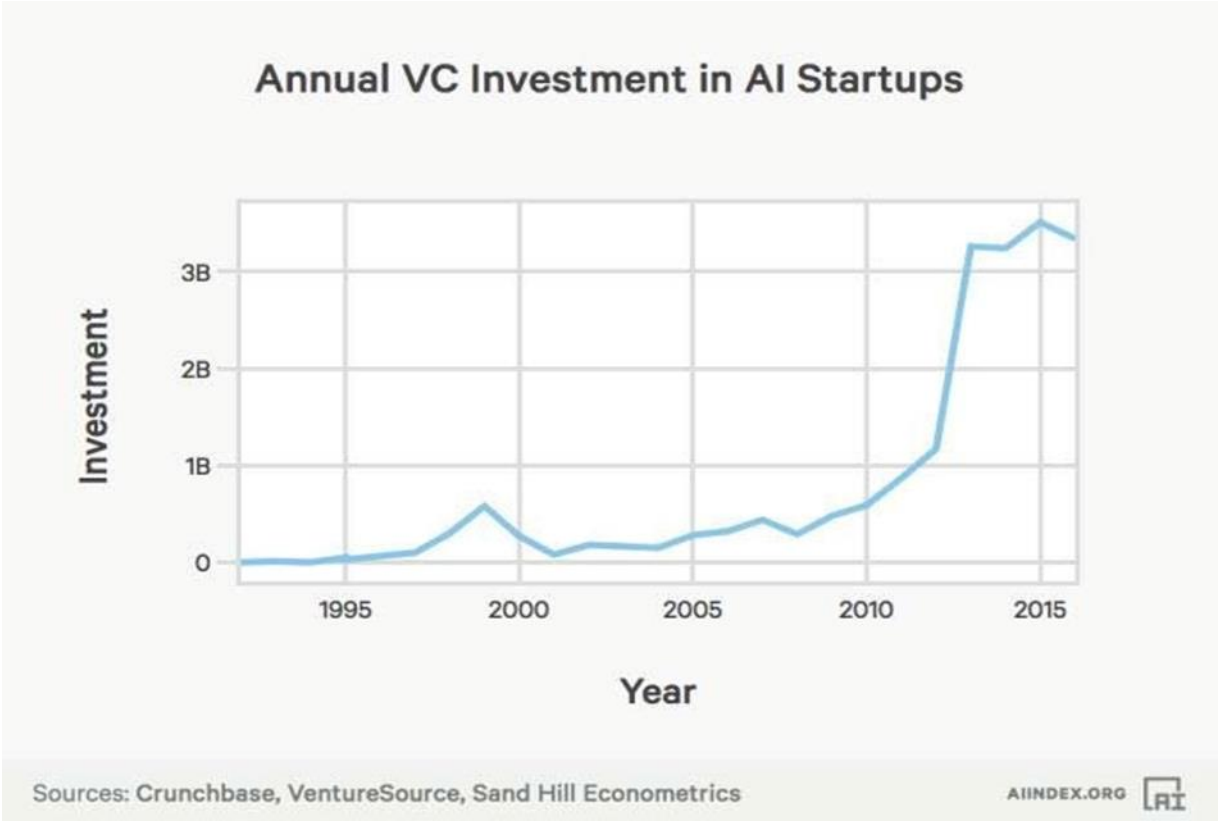
Revenues from the artificial intelligence for enterprise applications market worldwide, from 2016 to 2025 (in million U.S. dollars)



statista




Startups Developing AI Systems
Active Startups
600
400
200
0
1995
2000
2005
2010
2015
Year
Sources: Crunchbase, VentureSource, Sand Hill Econometrics
AIINDEX.ORG


Annual VC Investment in AI Startups
Investment
3B
2B
1B
0
1995
2000
2005
2010
2015
Year
Sources: Crunchbase, VentureSource, Sand Hill Econometrics
AIINDEX.ORG

Student Survey in Undergraduate AI Course

The survey was circulated to students taking an undergraduate class of artificial intelligence. Ten participants out of a class of twenty responded. All ten students were very positive about the role of artificial intelligence in the society, and supported "MS degree in Artificial Intelligence". Nine students showed an interest in pursuing a "Master in Artificial Intelligence". The support was overwhelming in all three areas: *intelligent analytics, automation of machines and robotics*, and *smart communities*.

Survey Template

Student Survey for MS in AI program

1. Machine learning	*2. AI in games*	*3. AI programming*
4. Intelligent analytics in fraud detection	*5. AI in weather prediction*	*6. AI in industrial robots*
7. AI in humanoid robots	*8. AI in motion planning and control*	*9. AI in environmental health*
10. AI in process automation	*11. AI in transportation*	*12. AI in smart homes*
13. AI in smart energy distribution	*14. AI in health management*	*15. Ai in hazard recovery*
16. AI in space exploration	*17. AI in intelligent communication systems*	*18. AI in Health care and biosignal analysis*
19. Robots for elderly care	*20. AI in manufacturing*	*21. Decision support systems*

1. *Are you interested or intrigued by artificial intelligence? Yes/ No*
2. *Do you plan to take* (or taking) *an AI-related courses? Yes / no*

   (Examples: Artificial Intelligence; Machine Learning; Robotics; Data mining; Big data analytics, etc.)
3. *Do you think artificial intelligence will help in improving the society of future? Yes / No*
   Please justify your answer briefly:
4. *Knowing there is a steep increase in demand and salary of AI graduates, will you consider "MS in Artificial Intelligence" after your graduation? Yes/ No*
5. *Which areas do you think AI can be applied?* ***Circle as many as you like. Fill more if needed***
6. *Knowing that smart devices are being embedded in daily usage machines, will you like to learn more in a focused way about artificial intelligence? Yes / No*
7. *Which all AI areas do you think will have significant impact on society in the next twenty years?* ***Circle as many as you will like.***

   I intelligent analytics of data and process.

   II automation of machines and robotics.

   III Smart homes, smart transportation, smart health management, smart cities, etc.
8. *If you would like to go to a graduate program, will you consider getting admission in our or any other program with "MS in Artificial Intelligence"? Yes / No*
9.

Survey of Junior and Senior CS Students

A detailed survey of junior and senior students in the Department of Computer Science was conducted. 221 students responded. The response was overwhelmingly positive. 86% students showed interest in taking AI course. 85% of students showed interest in attending "MS in Artificial Intelligence." 98% of students supported the creation of a Master of Science degree in artificial intelligence within the Department of Computer Science.

Question	Yes	No
1. Would you be interested in learning more about artificial intelligence and career opportunities in artificial intelligence?	186 (86%)	35(14%)
2. Would you be interested in taking artificial intelligence courses at the graduate or undergraduate level?	184 (85%)	38(15%)
3. Would it be a good idea for KSU to begin an "MS in Artificial Intelligence"?	216 (98%)	5 (2%)

Appendix C. National Norms of Underrepresented Students in Computer Science

(CRA Taulbee Report 2017)

National Norms in Bachelor's Program

Abbreviations: CS – Computer Science; **CE** – Computer Engineering; **I** - Informatics

Table M7. Masters Degrees Awarded by Gender and Ethnicity, From 163 Departments Providing Breakdown Data

	CS					CE					I					Ethnicity Totals	
	Male	Fem	N/R	% of M*	% of F*	Male	Fem	N/R	% of M*	% of F*	Male	Fem	N/R	% of M*	% of F*	Total	%
Nonresident Alien	6,094	2,462	257	71	81	514	161	0	74	83	923	595	71	57	43	11,077	69.2
Amer Indian or Alaska Native	13	10	0	0	0	0	0	0	0	0	1	1	0	0	0	25	0.2
Asian	641	272	8	7	9	31	10	0	5	5	137	109	6	8	8	1214	7.6
Black or African-American	87	24	0	1	1	8	1	0	1	1	68	61	8	4	4	257	1.6
Native Hawaiian/ Pac Islander	3	0	0	0	0	1	0	0	0	0	1	0	1	0	0	6	0.0
White	1,579	250	13	18	8	110	16	0	16	8	436	529	75	27	38	3,008	18.8
Multiracial, not Hispanic	51	9	2	1	0	8	2	0	1	1	19	34	5	1	3	130	0.8
Hispanic, any race	139	32	2	2	1	22	3	0	3	2	46	49	7	3	4	300	1.9
Total Res & Ethnicity Known	8,607	3,059	282			694	193	0			1,631	1,378	173			16,017	
Resident, ethnicity unknown	228	61	18			8	4	0			47	42	0			408	
Not Reported (N/R)	121	42	619			8	3	0			12	2	17			824	
Gender Totals	8,956	3,162	919			710	200	0			1,690	1,422	190			17,249	
%	73.9%	26.1%				78.0%	22.0%				54.3%	45.7%					

* % of M and % of F columns are the percent of that gender who are of the specified ethnicity, of those whose ethnicity is known

Table M2. Master's Degrees Awarded by Gender

	CS		CE		I		Total	
Male	8,956	73.9%	710	78.0%	1,690	54.3%	11,356	70.4%
Female	3,162	26.1%	200	22.0%	1,422	45.7%	4,784	29.6%
Total Known Gender	12,118		910		3,112		16,140	
Gender Unknown	919		0		190		1,109	
Grand Total	13,037		910		3,302		17,249	

Table M3. Master's Degrees Awarded by Ethnicity

	CS		CE		I		Total	
Nonresident Alien	8,813	73.8%	675	76.1%	1,589	49.9%	11,077	69.2%
Amer Indian or Alaska Native	23	0.2%	0	0.0%	2	0.1%	25	0.2%
Asian	921	7.7%	41	4.6%	252	7.9%	1,214	7.6%
Black or African-American	111	0.9%	9	1.0%	137	4.3%	257	1.6%
Native Hawaiian/Pac Island	3	0.0%	1	0.1%	2	0.1%	6	0.0%
White	1,842	15.4%	126	14.2%	1,040	32.7%	3,008	18.8%
Multiracial, not Hispanic	62	0.5%	10	1.1%	58	1.8%	130	0.8%
Hispanic, any race	173	1.4%	25	2.8%	102	3.2%	300	1.9%
Total Residency & Ethnicity Known	11,948		887		3,182		16,017	
Resident, ethnicity unknown	307		12		89		408	
Residency unknown	782		11		31		824	
Grand Total	13,037		910		3,302		17,249	

Table D9. PhDs Awarded by Gender and Ethnicity, From 154 Departments

	CS					CE					I					Ethnicity Totals	
	Male	Fem	N/R	% of M*	% of F*	Male	Fem	N/R	% of M*	% of F*	Male	Fem	N/R	% of M*	% of F*	Total	%
Nonresident Alien	727	164	0	62	63	48	6	0	55	60	33	9	0	46	19	987	59.9
Amer Indian or Alaska Native	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0.0
Asian	103	27	0	9	10	15	1	0	17	10	6	6	0	8	13	158	9.6
Black or African-American	6	4	0	1	2	0	0	0	0	0	3	5	0	4	10	18	1.1
Native Hawaiian/ Pac Islander	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2	2	0.1
White	307	64	0	26	25	21	3	0	24	30	26	22	0	36	46	443	26.9
Multiracial, not Hispanic	4	0	0	0	0	1	0	0	1	0	2	0	0	3	0	7	0.4
Hispanic, any race	22	2	0	2	1	2	0	0	2	0	2	5	0	3	10	33	2.0
Total Res & Ethnicity Known	1,170	261	0	0	0	87	10	0			72	48	0			1,648	
Resident, ethnicity unknown	76	15	0			1	0	0			2	2	0			96	
Not Reported (N/R)	52	15	3			10	2	0			4	0	4			90	
Gender Totals	1,298	291	3			98	12	0			78	50	4			1,834	
%	81.7%	18.3%				89.1%	10.9%				60.9%	39.1%					
* % of M and % of F columns are the percent of that gender who are of the specified ethnicity, of those whose ethnicity is known																	

Appendix D. Master of Science in AI in National and International Universities (partial list)

MS in AI-related Program in National Universities (partial list)

	US University	MS Program Name
1.	Carnegie Mellon University	1. Artificial Intelligence and Innovation; 2. Intelligent Information Systems; 3. Machine learning; 4. Robotics; 5. Computer Vision; 6. Human-computer Interaction
2.	University of Georgia	1. Artificial Intelligence
3.	Columbia University	1. Machine learning;
4.	Indiana University	1. Intelligent Systems Engineering;
5.	Northwestern University	1. Artificial Intelligence
6.	University of Southern California	1. Intelligent robotics
7.	University of North Carolina at Chapel Hill	1. Artificial Intelligence

Note: In addition to US universities offering MS programs in Artificial Intelligence, many universities offer Artificial Intelligence track as a concentration within Computer Science.

MS in AI-related Program in International Universities (partial list)

	University	MS Program Name
1.	University of Edinburgh (UK)	1. Artificial Intelligence
2.	University of Birmingham (UK)	1. Human computer interaction; 2. Robotics; 3. Cognitive Robotics and Cognitive Psychology
3.	University of Sussex (UK)	1. Intelligent and adaptive systems
4.	K. P. Leuven University (Belgium)	1. Artificial Intelligence
5.	Barcelona School of Informatics (Spain)	1. Artificial Intelligence
6.	University of Rome (Italy)	1. Artificial Intelligence and Robotics
7.	Utrecht University (Netherlands)	1. Artificial Intelligence
8.	University of Amsterdam (Netherlands)	1. Artificial Intelligence
9.	Tampere University (Finland)	1. Robotics and Artificial Intelligence
10.	Technical University of Munich (Germany)	1. Robotics, Cognition and Intelligence
11.	Tokyo Institute of Technology (Japan)	4. Artificial Intelligence

Appendix E. Master of Science in AI in Comparable Universities

Status of Masters of Science in Artificial Intelligence in Ohio Universities

	University	Status of MS degree in AI
1.	Ohio State University	No independent MS degree in AI (CS-subarea)
2.	Case Western Reserve University	No independent MS degree in AI (cs-subarea) Minor in AI within BS (CS) program
3.	University of Cincinnati	Master of Engineering in Artificial Intelligence
4.	Wright State University	No independent MS degree in AI (CS-subarea)
5.	Ohio University	No independent MS degree in AI (CS-subarea)
6.	Cleveland State University	No independent MS degree in AI (CS-subarea)

Status of Masters of Science in AI in Comparable National Universities

	University / Status	Status
1.	Georgia State University	No independent MS degree in AI. AI is subarea of Computer Science.
2.	University of Houston	No independent MS degree in AI. Data Analytics track within MS in Computer Science
3.	Western Michigan University	No independent MS degree in AI. AI is subarea of Computer Science
4.	North Texas University	No independent MS degree in AI. AI is subarea of Computer Science
5.	Utah State University	No independent MS degree in AI. AI is subarea of Computer Science
6.	Clemson University	No independent MS degree in AI. AI is subarea of Computer Science
7.	Penn State University	No independent MS degree in AI. AI is subarea of Computer Science
8.	University of South Florida	No independent MS degree in AI. AI is subarea of Computer Science
9.	Temple University	No independent MS degree in AI. AI is subarea of Computer Science
10.	Virginia Commonwealth University	No independent MS degree in AI. AI is subarea of Computer Science

Appendix F. Associated Faculty / AI Courses Taught

	PhD Faculty	List of Courses to be taught in the Master in AI
1.	Arvind Bansal	CS 54201 – Artificial Intelligence CS 63100 – Computational Health Informatics CS 64201 – Advanced Artificial Intelligence CS 64402 – Multimedia Systems and Biometrics
2.	Michael Carl	CS 6XXXX – Natural Language Processing (under dev.)
3.	Qiang Guan	CS 63005 – Advanced Database Systems Design
4.	Ruoming Jin	CS 54202 – Principles of Machine Learning CS 63015 – Data Mining Techniques CS 63016 – Big Data Analytics
5.	Jong-Hun Kim	CS 53301 – Software Development for Robotics CS 53334 – Human-Robot Interaction
6.	JungYoon Kim	CS 53305 – Advanced Digital Design CS 63306 – Embedded Computing
7.	KwangTaek Kim	CS 57201 – Human-Computer Interaction CS 69099 – Capstone Projects
8.	Xiang Lian	CS 63018 – Probabilistic Data Management. CS 63016 – Big Data Analytics
9.	Cheng Chang Lu	CS 64301 – Pattern Recognition Principles CS 64401 – Image Processing
10.	Hassan Peyravi	CS 65203 – Wireless and Mobile Communications Networks
11.	Augustus Samba	CS 53305 – Advanced Digital Design
12.	Gokarna Sharma	CS 53302 – Algorithmic Robotics CS 53303 – Internet of Things
13.	Ye Zhao	CS 64301 – Pattern Recognition Principles CS 67301 – Scientific Visualization. CS 67302 – Information Visualization

Appendix G. Fiscal Impact Sheet

	Year 1	Year 2	Year 3	Year 4
I. Projected Enrollment				
Headcount full-time (1)	10	25	35	40
Headcount part-time	0	0	0	0
Full-time equivalent (FTE) enrollment	10	25	35	40
II. Projected Program Income				
Tuition (2)	$ 168,590	$ 421,475	$ 590,065	$ 674,360
Expected state subsidy (3)	$ 67,436	$ 168,590	$ 236,026	$ 269,744
Externally funded stipends, as applicable	$ -	$ -	$ -	$ -
Other Income	$ -	$ -	$ -	$ -
Total Projected Program Income	**$ 236,026**	**$ 590,065**	**$ 826,091**	**$ 944,104**
III. Program Expenses (4)				
New personnel:				
- Instruction				
Full-time:	$ -	$ -	$ -	$ -
Part-time:	$ -	$ -	$ -	$ -
-Non-instruction				
Full-time:	$ -	$ -		
Part-time:	$ -	$ -	$ -	$ -
Current personnel:				
- Instruction				
Full-time:	$ -	$ -	$ -	$ -
Part-time:	$ -	$ -	$ -	$ -
-Non-instruction				
Full-time:	$ -	$ -	$ -	$ -
Part-time:	$ -	$ -	$ -	$ -
Benefits for all personnel	$ -	$ -	$ -	$ -
New facilities/building/space renovation (describe in narra	$ -	$ -	$ -	$ -
Scholarship/stipend support	$ -	$ -	$ -	$ -
Additional library resources	$ -	$ -	$ -	$ -
Additonal technology or equipment needs	$ -	$ -	$ -	$ -
Other expenses (see below)	$ -	$ -	$ -	$ -
Total Projected Program Expenses	**$ -**	**$ -**	**$ -**	**$ -**
Projected Program Net	**$ 236,026**	**$ 590,065**	**$ 826,091**	**$ 944,104**

Other Expenses				
Allocation of expenses covered by general fee (5)	$ 36,844	$ 92,109	$ 128,953	$ 147,375
RCM overhead - estimated at 50% (6)	$ 99,591	$ 248,978	$ 348,569	$ 398,365
RCM tuition allocation to other colleges	$ -	$ -	$ -	$ -
Professional development	$ -	$ -	$ -	$ -
Supplies (office, computer software, duplication, printing)	$ -	$ -	$ -	$ -
Telephone, network, and lines	$ -	$ -	$ -	$ -
Other info and communication pool	$ -	$ -	$ -	$ -
Total Other Expenses	**$ 136,435**	**$ 341,087**	**$ 477,522**	**$ 545,739**

BUDGET NARRATIVE:

(1) 10 students in the initial cohort; increasing to 15 in the second cohort (while the initial cohort is in Year 2); then increasing to 20 students for the subsequent cohorts. By Year 4, the total number of students stabilizes at 40.

(2) Projection based on half of the students qualifying for in-state tuition and half not.

(3) The State contribution is estimated at 40% of the tuition amount.

(4) Not applicable - no new resources needed

(5) Using the Estimate Percentage Distribution of Instructional and General Fee FY 19/20, Kent Campus: General Fee: 15.61%

(6) 50% of the Projected Program Net, after subtracting the Allocation of expenses covered by the general fee.

Appendix H. Letters of Support

Professor Arvind Bansal
Department of Computer Science
Kent State University
Kent, OH 44242, USA

11/21/18

Dear Professor Bansal.

Thank you for reaching out to us at Dark Rhino Security. We are a cybersecurity company based in Columbus, Ohio with a corporate presence in Pittsburgh, Pa and London, UK, and Madrid, Spain. Our team is involved in intelligent analytics and application of artificial intelligence to provide state of the art cybersecurity solutions to provide evidence by management AI systems to the commercial and military sectors. Functional systems based on designs conceived by our senior scientist are in use in government security applications in the EU.

We see the growth of artificial intelligence market in various domains. We believe the management by evidence systems that interlink many AI approaches like cognitive processing, natural language processing, edge detection, etc. into a single unified neural net are the future. The applications in the Cyber Security field are many and we have only begun to scratch the surface. The described approach to neural nets can be applied not only to Cyber Security but to other commercial industries ranging from consumer products to finance to medicine. We endeavor to help our clients, across industries, to achieve their business goals by making significant and lasting improvements to security and financial performance.

With the anticipated growth of application of AI, we anticipate that there will be a significant growth in the demand of graduates focused in AI and intelligent analysis. We will be very interested in seeing specific programs that train AI graduates. We support Kent State University's endeavor to develop an exclusive MS program in Artificial Intelligence.

Sincerely

Manoj Tandon

EVP, Chief Sales Strategy Officer

DARK RHINO
SECURITY
5695 Avery Road, Dublin, OH 43016
614.401.3025

Support Letter from Major IBM Research Center in Watson, New York, NY

Manoj Kumar
IBM Thomas J. Watson Research Center
1101 Kitchawan Road/Route 134
Yorktown Heights, New York 10598
Phone: 914-945-1417
Fax: 914-945-4425
E-mail: manoj1@us.ibm.com

November 28, 2018

Professor Arvind Bansal
Department of Computer Science
Mathematical Sciences Building
Kent State University
Kent, OH 44242

Dear Arvind,

It is a pleasure to write this letter in support of the creation of a Master in Artificial Intelligence program in the department of Computer Science at Kent University.

IBM has a long history of cutting edge research in artificial intelligence, from the chess champion Deep Blue to the Jeopardy champion IBM Watson. IBM is bringing many of its such artificial intelligence innovations to market through a broad array of product offerings such as IBM Watson Health and IBM PowerAI. Existing applications in health care, homeland security, financial fraud prevention, focused product recommendations, etc., are incorporating AI technologies at an accelerating pace to generate additional value for their end users. Analysis of vast amount of multi-modal data to develop actionable insights or comprehensive models is at the heart of this effort. Deploying these insights or models into ubiquitous end user devices and applications is another important aspect of artificial intelligence applications.

Emerging applications such as autonomous vehicles or robotics for elderly care are based on automated learning from vast amounts of observational or training data. These applications are driving disruptive transformations in the automotive and elderly care industries. The AI technology required by these applications include innovations across the board in computer science, starting from high performance systems to meet the computing power required for the learning/training aspects of artificial intelligence, low power light weight inferencing systems using that apply these models to observed data, programming environments, both development and runtimes which make efficient use of these applications, and the data mining and machine learning techniques underlying these applications. Algorithms to analyze the vast amounts of multi-model data efficiently, in terms of computational complexity, are also a critical part of the artificial intelligence research.

While the industry is finding the artificial intelligence skills in short supply, traditional computer science skills such as IT services management and application support are increasingly becoming redundant as they get embodied in artificial intelligence software. Over the last decade at IBM, I have lead the Data Management Technical Strategy as Program Director, and lead the research in Analytics Systems, also as Program Director. In these positions I have played a significant role in adaption of technologies that fall under the broad umbrella of artificial intelligence (AI) in a broad range of IBM products. I believe that the trend of incorporating AI will accelerate in future.

The creation of a Master in Artificial Intelligence program will be a major step in creating a future workforce critical to the needs of US economy, not to mention that the students enrolling in this program can look forward to professionally satisfying and economically rewarding careers.

Regards,

Manoj Kumar
Program Director, Analytics Systems

Support Letter from First PhD Alumni in AI

(Employed in NASA Glenn Research Center, Cleveland, Ohio, since 2001)

Professor Arvind Bansal
Department of Computer Science
Kent State University
Kent, OH 44242, USA

November 7, 2018

Dear Professor Bansal.

Thank you for reaching out to me.

As you know, I finished my PhD in Computer Science at Kent State in 2001. With your support and that of the department, I was able to complete my dissertation in which I developed a distributed knowledge-based modeling environment and demonstrated its application to aircraft engine design. That research was a collaboration with NASA Glenn Research Center by way of a Graduate Student Research Program (GSRP) fellowship and subsequently led to a permanent position with NASA Glenn, where I am still employed as an aerospace technologist today.

Lately, I have seen increased interest here in the research community in applying recent advances in machine learning to engineering problems such as noise prediction for aircraft engines and computational fluid dynamics. While companies such as Google, Tesla and Amazon have been developing and applying these technologies for a while, it is a new and promising approach to some of the optimization and design problems we see in aerospace. As someone who travels the Ohio Turnpike on a daily basis, I am also aware that the Ohio Department of Transportation (ODOT) is involved in a long term project in which it aims to be a leader in "Smart Mobility" and autonomous driving.

I understand that there is a proposal at hand for a new MS in Artificial Intelligence within the Department of Computer Science. I think the availability of such a specialized degree program at Kent State could create a valuable pool of talent to supply the growing interest in this technology in both government and industry. I have identified only two specific examples that I am aware of here in our local area, but I expect that opportunities for graduates with AI-related degrees are much greater and will only continue to increase.

I think the proposed degree program is timely and would serve prospective students and their future employers well. I wish you in the department and at the university great success with this program.

Sincerely,

Stephen W. Ryan

Support Letters from Related Academic Disciplines

Support Letter from Department of Biological Sciences

KENT STATE UNIVERSITY

March 1, 2019

To whom it may concern:

On behalf of the Department of Biological Sciences, I am pleased to offer support of the proposed MS in Artificial Intelligence. The Computer Science Department is well positioned to offer this new degree.

We are excited about the potential for collaboration afforded by this new program. We are eager to support and interact with the Computer Science program as this new degree moves forward.

Sincerely,

Laura G. Leff
Professor, Chair
Biological Sciences

Support Letter from Department of Psychological Sciences

KENT STATE UNIVERSITY

March 7, 2019

To whom it may concern:

I have reviewed the proposal to establish an MS in Artificial Intelligence, and I am very pleased to provide my strong support. The Computer Science Department is very well positioned to offer this new degree. The Department of Psychological Sciences is excited about the many opportunities for collaboration that this new program provides, and we are eager to support the program as this new degree moves forward.

Sincerely,

Maria S. Zaragoza
Professor and Chair
Department of Psychological Sciences

Department of Psychological Sciences
P.O. Box 5190 • Kent, Ohio 44242-0001
330-672-2166 • Fax: 330-672-3786 • http://www.kent.edu

Support Letter from the Department of Modern and Classical Languages

KENT STATE UNIVERSITY

September 20, 2019

Dear Chair Khan,

I am writing to express the strong support of the Department of Modern and Classical Language Studies for the creation of the proposed MS in Artificial Intelligence in Computer Science. Natural Language interfaces and translation are key to human and intelligent machine interfaces. In addition, natural language translation and natural language understanding are part of Artificial Intelligence research and curricula. Consequently, I am confident that we can enhance our collaboration through this new degree.

Our departments already share Professor Michael Carl, who has distinguished himself in the areas of machine translation of natural languages, cognitive aspects of natural language translation and man-machine interfaces. We are very excited about this new program, which will deepen our mutually beneficial collaboration.

Sincerely,

Keiran J. Dunne
Professor and Chair
Department of Modern and Classical Languages

Modern and Classical Language Studies
P.O. Box 5190 • Kent, Ohio 44242-0001
330-672-2150 • Fax: 330-672-4009 • http://www.kent.edu/mcls

Support Letter from College of Aeronautics and Engineering

Re: Proposed MSAI Program Curriculum

Subject: Re: Proposed MSAI Program Curriculum
From: "Bloebaum, Christina" <cbloebau@kent.edu>
Date: 11/12/2019 9:46 AM
To: "Javed I. Khan" <javedkent@gmail.com>, "VAN DULMEN, MANFRED" <mvandul@kent.edu>
CC: "KHAN, JAVED" <javed@kent.edu>, "TILLETT, THERESE" <ttillet1@kent.edu>, "BLANK, JAMES" <jblank@kent.edu>, "Haley, Mary Ann" <mhaley@kent.edu>

Dear Javed,

I apologize that it has taken us this long to do a thorough review. It was critical that all my new faculty consider this. I have iterated with all our relevant faculty on the proposal. We are excited to see this program. There are a few points we are hoping we can work out as the complete proposal is developed. Our understanding is that this is the initial inquiry. If I am incorrect, please let me know!

First, I am sure everyone is aware that AI is an area of research that certainly fits solidly in CS, but also is a big research area within engineering. For instance, AI was part of my own PhD dissertation (30 years ago!), is presently a huge part of my PhD student's work back in Iowa. It is a critical area of research in systems design, autonomous systems, and many areas across engineering. Almost every one of my new hires has research in AI. Hence, the biggest concern from our college and our faculty engaged in relevant research (all our new faculty, for instance) is that there not be a message sent that the only place at Kent State to do AI research is in CS.

Our faculty are hopeful that a few things might be considered by the CS faculty and administrators.

First, is there any way to slightly modify the name of the concentration so that it is not all inclusive? We ask that it be considered.

Second, our own faculty are developing courses that would fit extremely well within this curriculum as electives. Our faculty are looking forward to having their students take many of these courses as electives. We are proposing a win-win. My faculty ask that the CS faculty and administrators consider whether there can be more room in the degree to enable students to take relevant electives in our college. We will do the same from our end as our MS/PhD proposals move forward. For instance, many of these courses would be perfect for our MS/PhD degrees in both Aerospace Engineering and Mechatronics Engineering. Here are the courses being developed in the next year or two, as an example of relevance. Deep Learning for Autonomous Robotics, Deep Reinforcement Learning for Human-Robot Swarm Interaction, Computer and Robot Vision, and others.

Again, we fully support this program and look forward to working with CS faculty and administrators as this moves forward.

Please let me know what kind of letter would be needed as this moves forward.

I hope this is helpful,

Christina

Christina L. Bloebaum
Dean
College of Aeronautics and Engineering

330-672-0790
cbloebau@kent.edu

From: Javed I. Khan <javedkent@gmail.com>
Sent: Wednesday, November 6, 2019 6:08 PM
To: VAN DULMEN, MANFRED <mvandul@kent.edu>; Bloebaum, Christina <cbloebau@kent.edu>; Spake, Deborah <dspake@kent.edu>; Reynolds, Amy <areyno24@kent.edu>
Cc: KHAN, JAVED <javed@kent.edu>; TILLETT, THERESE <ttillet1@kent.edu>; BLANK, JAMES <jblank@kent.edu>; Haley, Mary Ann <mhaley@kent.edu>
Subject: Re: Proposed MSAI Program Curriculum

Just noted while opening the file the document might be difficult to read with few review format issue.
Here is a fixed version- and should be easier to ready..

Best,

-Javed.

VAN DULMEN, MANFRED wrote:

> Christina, Deborah, & Amy:
>
> Attached is the latest version of the MSAI proposed curriculum. I understand Javed would like to have this proposal (Program Development Plan, initial inquiry) discussed at EPC in the near future (I had circulated a previous version of this proposal this past May). Could you take a look at the proposal and let Javed and me know whether you or your faculty have any major concerns/whether there is a need to meet. As always, the specifics of the proposal can be worked out as they work on the full proposal. Ideally, could you let us know thoughts/concerns/questions by the end of November? Please also let me know if you have any concerns about the timeline. Thanks in advance,
>
> ---
> Manfred H. M. van Dulmen, PhD
> Interim Associate Provost for Academic Affairs
> Office of the Provost (2nd Floor Library)
> Kent State University OH 44242 USA
> 330-672-3115 mvandul@kent.edu

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Dr. Javed I. Khan, Professor and Chair
Department of Computer Science
Kent State University, 241 MSB, Kent, OHIO-44242, USA
Tel: (330)-672-9055, Fax:(330)-672-0737
Email: javed@cs.kent.edu
Home page: http://www.cs.kent.edu/~javed

Support Letter from College of Communication and Information

From: Reynolds, Amy <areyno24@kent.edu>
Sent: Wednesday, December 11, 2019 11:02 AM
To: VAN DULMEN, MANFRED <mvandul@kent.edu>; Spake, Deborah <dspake@kent.edu>
Cc: KHAN, JAVED <javed@kent.edu>; TILLETT, THERESE <ttillet1@kent.edu>; BLANK, JAMES <jblank@kent.edu>; Haley, Mary Ann <mhaley@kent.edu>
Subject: Re: Proposed MSAI Program Curriculum

Hi Manfred,

I have no additional comments and support the pre-proposal.

Thanks,

Amy

From: "VAN DULMEN, MANFRED" <mvandul@kent.edu>
Date: Wednesday, December 11, 2019 at 8:36 AM
To: "Spake, Deborah" <dspake@kent.edu>, "Reynolds, Amy" <areyno24@kent.edu>
Cc: "KHAN, JAVED" <javed@kent.edu>, "TILLETT, THERESE" <ttillet1@kent.edu>, "BLANK, JAMES" <jblank@kent.edu>, "Haley, Mary Ann" <mhaley@kent.edu>
Subject: RE: Proposed MSAI Program Curriculum

Deb & Amy: CS has feedback from CAE on this proposal. do you have any additional comments or would you support this pre-proposal to go to EPC in January? As a reminder, this is just a pre-proposal and will be an information item on the EPC agenda. units can also be consulted as the full proposal is being developed. Thanks,

---

Manfred H. M. van Dulmen, PhD

Interim Associate Provost for Academic Affairs

Office of the Provost (2nd Floor Library)

Kent State University OH 44242 USA

330-672-3115 mvandul@kent.edu

Appendix I. Course Descriptions

CS 53301 SOFTWARE DEVELOPMENT FOR ROBOTICS 3 Credit Hours
Robots are being used in multiple places that are not easily accessible for humans, to support the lack of available labor, to gain extra precision, and for cost effective manufacturing processes, monitoring, space exploration, precision surgery and artificial limb support for elderly and physically challenged persons. Computer science is an integral part of robotics as it includes areas such as computer algorithms, artificial intelligence, and image processing that are essential aspects of robotics. This first course on robotics will teach the students various motions of rigid robots, mathematics and algorithms related to these motions, motion planning, obstacle avoidance, intelligent path planning including use of various sensors.
Prerequisite: Graduate Standing.
Schedule Type: Lecture and Lab **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 53302 ALGORITHMIC ROBOTICS 3 Credit Hours
This course provides students theoretical, mathematical, and practical foundations for the design, analysis, and evaluation of algorithms for robots for diverse robotic applications. We will focus on a principled and mathematically sound approach to the design of algorithms for robots rather than ad hoc and hacking development approaches.
Prerequisites: Graduate Standing
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 53303 INTERNET OF THINGS 3 Credit Hours
This course will provide a comprehensive understanding of the Internet of Things by looking into a variety of real-world application scenarios, existing and new technologies and architectures, communication protocols and standardization efforts, societal and behavioral changes, and how to apply these technologies to tackle real-world problems.
Prerequisite: Graduate Standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 53305 ADVANCED DIGITAL DESIGN 3 Credit Hours
This course describes techniques in the design of digital systems. Topics covered include combinational and sequential logic, gate-level minimization, registers and counters, memory and programmable logic, hardware description languages, digital communication including serial and parallel and synchronous and asynchronous methods.
Prerequisite: Graduate standing
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 53334 HUMAN-ROBOT INTERACTION 3 Credit Hours
Human-Robot Interaction (HRI) is the study of interactions between humans and robots dedicated to understanding, designing, and evaluating robotic systems for use by and with humans. HRI is a multidisciplinary field that incorporates human-computer interaction, artificial intelligence, robotics, natural language understanding, design, and social sciences. Interaction between humans and robots may take several forms, but are generally categorized by how close in proximity the humans and robots are to each other such as remote, proximate, and hybrid interaction. In the class, students will learn the fundamental technologies and theories in each category, and blend this knowledge with various case studies and lab activities. Prerequisites: Graduate Standing
Prerequisite: Graduate standing and CS 53301
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 54201 ARTIFICIAL INTELLIGENCE 3 Credit Hours
Examines goals, problems, concepts and methods of artificial intelligence heuristic versus algorithmic methods, natural language comprehension, theorem proving.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 54202 Principles of Machine Learning 3 credit Hours (approved)
This introductory course will provide an overview of some fundamental concepts, techniques and algorithms in machine learning & deep learning, and will give students a basic understanding (ideas and intuitions) of how modern machine learning works. Specifically, we have three main objectives: 1. To help students get familiar with the fundamental mathematical tools (linear algebra, probability theory, statistical inference, numerical optimization, and learning theory) which lays the foundation of machine learning algorithms and techniques; 2. To introduce the core machine learning concepts and topics, such as linear regression, classification, SVM, and neural networks (and its deep variants); In addition, we will utilize the recommendation system for students to learn how real world machine system works; 3. Teach students how to program and use the latest machine learning packages, such as Tensorflow.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 57201 HUMAN COMPUTER INTERACTION 3 Credit Hours
Approaches the human-computer interaction as an activity of the human whose productivity is increased by the use of the computer as a tool. Examines physiology and psychology considers the structure and operation of the computer and models the interaction between the two.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63005 ADVANCED DATABASE SYSTEMS DESIGN 3 Credit Hours
Introduction to a variety of advanced database topics and on-going trends in modern database systems. The course includes advanced issues of object-oriented database, XML, advanced client server architecture and distributed database techniques.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63015 DATA MINING TECHNIQUES 3 Credit Hours
Concepts and techniques of data mining. Data mining is a process of discovering information from a set of large databases. This course takes a database perspective on data mining.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63016 BIG DATA ANALYTICS 3 Credit Hours
Introduces computing platforms with focus on how to use them in processing, managing and analyzing massive datasets. Utilizes several key data processing tasks, including simple statistics, data aggregation, join processing, frequent pattern mining, data clustering, information retrieval, page-rank and massive graph analytics as the case study for large scale data processing.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63017 BIG DATA MANAGEMENT 3 Credit Hours
This course will cover a series of important Big-Data-related problems and their solutions. Specifically, we will introduce the characteristics and challenges of the Big Data, state-of-the-art computing paradigm sand platforms (e.g., MapReduce), big data programming tools (e.g., Hadoop and MongoDB), big data extraction and integration, big data storage, scalable indexing for big data, big graph processing, big data stream techniques and algorithms, big probabilistic data management, big data privacy, big data visualizations, and big data applications (e.g., spatial, finance, multimedia, medical, health, and social data).
Prerequisite: Graduate Standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63018 PROBABILISTIC DATA MANAGEMENT 3 Credit Hours
This course addresses the fundamental concepts and techniques for probabilistic data management in the area of databases. Probabilistic data are pervasive in many real-world applications, such as sensor networks, GPS system, location-based services, mobile computing, multimedia databases, data extraction and integration, trajectory data analysis, semantic web, privacy preserving, and so on. This class also covers major research topics such as probabilistic or uncertain data models, probabilistic queries, probabilistic query answering techniques, and data quality issues in databases.
Prerequisite: Graduate Standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63100 COMPUTATIONAL HEALTH INFORMATICS 3 Credit Hours
The course describes computational techniques and software tools for managing and transmitting health related information and automated analysis of medical and biosignal data. Prerequisites: Graduate Standing
Prerequisite: Graduate Standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 63306 EMBEDDED COMPUTING 3 Credit Hours
Computational issues structuring programs for processors embedded in other devices, such as those found in automobiles and biological and chemical sample processing devices.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 64201 ADVANCED ARTIFICIAL INTELLIGENCE 3 Credit Hours
Additional topics in AI such as logic programming, advanced problem-solving systems, understanding natural languages, vision, learning, plan-generating systems.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 64301 PATTERN RECOGNITION PRINCIPLES 3 Credit Hours
Introduction to mathematical pattern recognition, feature selection, distribution-free classification, statistical classification, non-supervised learning, sequential learning and application.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 64401 IMAGE PROCESSING 3 Credit Hours
This course covers digital processing of digital imagery. Digitization of TV imagery, noise removal, image enhancement, edge and texture detection, object recognition and scene analysis.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 64402 MULTIMEDIA SYSTEMS AND BIOMETRICS 3 Credit Hours
This course discusses computational techniques for the fusion of multimedia data recorded by sensors for human-identification using automated analysis of biometric signals.
Prerequisite: Graduate Standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 65203 WIRELESS AND MOBILE COMMUNICATION NETWORKS 3 Credit Hours
Examines how wireless systems work and how mobile systems are supported by the underlying network infrastructure. Course covers the architecture and the interactions among different functional units in wireless and mobile systems.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 67301 SCIENTIFIC VISUALIZATION 3 Credit Hours
Discusses the visualization of scientific, engineering and medical data sets. Introduces mechanisms to acquire sampled or computed data and points out methods to transform these data into the visual system.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 67302 INFORMATION VISUALIZATION 3 Credit Hours
Information visualization is the science that unveils the underlying structure of data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system. In this class, we will study algorithms and systems for visually exploring, understanding, and analyzing large, complex data sets. Information visualization focuses on abstract data such as symbolic, tabular, networked, hierarchical, or textual information sources. The objectives of the course are to learn the principles involved in information visualization and a variety of existing techniques and systems. The students will also gain backgrounds and skills that will aid the design of new, innovative visualizations in realistic applications.
Prerequisite: Graduate standing.
Schedule Type: Lecture **Contact Hours:** 3 lecture **Grade Mode:** Standard Letter

CS 69192 GRADUATE INTERNSHIP 3 Credit Hours
Supervised work experience in Artificial Intelligence. Since this work will be outside the department a report and final presentation will be required; a site visit might also be needed.
Prerequisite: Special approval.
Schedule Type: Practicum or Internship **Contact Hours:** 3 other
Grade Mode: Satisfactory/Unsatisfactory or IP **Attributes:** Experiential Learning Requirement

CS 69099 CAPSTONE PROJECT 3 credit or 6 credit hours
The course is an integrative experience that brings together all components of the graduate Artificial Intelligence curriculum in an applied, hands-on real-world setting.
Prerequisite: Graduate standing
Schedule Type: Combined Lecture and Lab **Contact Hours: 3** credit
Grade Mode: Standard Letter **Attributes:** Experiential Learning Requirement

CS 69199 THESIS I 6 Credit Hours
Thesis student must register for a total of 6 hours, 6 hours distributed over one or more semesters. The thesis will be exclusive to the research in Artificial Intelligence (including focus areas) and its applications.
Prerequisite: Graduate standing.
Schedule Type: Master's Thesis **Contact Hours:** 6 credit
Grade Mode: Satisfactory/Unsatisfactory or IP

Appendix J. Curriculum Vitae of the Involved Faculty Members

Arvind K. Bansal, PhD
Full Professor (Computer Science)
Director — Artificial Intelligence Laboratory
Phone: +1 330-672-9035; **E-mail:** akbansal@kent.edu
Website: http://www.cs.kent.edu/~arvind

Research Contribution Areas

Artificial intelligence and intelligent agents, knowledge representation; biosignal analysis, multimedia systems; programming languages, parallel and distributed logic programming, bioinformatics, social robotics (humanoid gestures generation and emotion recognition), computational health informatics

Education

1979	B. Tech Electrical Engineering, Indian Institute of Technology, Kanpur, India.
1983	M.Tech. Computer Science and Engineering., Indian Institute of Technology, Kanpur, India.
1988	Ph.D., Computer Science and Engineering., Case Western Reserve University, Cleveland, USA.

Experience

2005 onwards	Full Professor, Computer Science, Kent State University, Kent, OH 44242, USA
1993-2005	Associate Professor, Computer Science, Kent State University, Kent, Ohio 44242, USA
1988-1993	Assistant Professor, Computer Science, Kent State University, Kent, Ohio, USA
Fall 2004	Visiting faculty, Dept of Computer Engineering, Benares Hindu University, India(on sabbatical)
Fall 2004	Visiting Faculty, Indian Institute of Technology at Kanpur, Kanpur, India, (on sabbatical)
Spring 1996	CRC Research Fellow, University of Melbourne. Melbourne, Australia, (on sabbatical)
Fall 1995	Visiting Faculty, EMBL Heidelberg, Germany, (on sabbatical)
Summer 1993	Summer Research Fellow, MCS Division, Argonne National Laboratory, IL, USA

Extramural Research Grants and Fellowships

- Extramural Research funded by NASA, Ohio Board of Regents, Wright Patterson Airforce Base and Air Force
- Fellowships from German Federal Agency and Australian Government
- Summer Faculty at Argonne National Laboratory, Illinois, USA

Selected Relevant Publications (Total Publications 75+)

1. A. Singh and A. K. Bansal, "A Declarative Model and an Inference Engine to Generate Non-emotional Head-based Conversational Gestures for Human-humanoid Interactions," *International Journal of Computers and Their Applications*, Vol. 26, No. 2, June 2019, pp. 49-66.
2. Purva R. Gawde, Arvind K. Bansal and J. Nielson "Integrating Markov Model, Bivariate Gaussian Distribution and GPU based Parallelism for Accurate Real-time Diagnosis of Arrhythmia Subclasses," *IEEE Future Technologies Conference* (*FTC*), Vancouver, BC, Canada, 13-14, November 2018, available as Book Series Intelligent Systems and Applications (AISC), K. Arai et. el. (Ed.), Vol. 880, 2019, Springer, pp. 569-588.
3. P. R. Gawde, A. K. Bansal, and J. Nielson, "Integrating Markov Model and Morphology Analysis for Automated Finer Classification of Ventricular Arrhythmia in Real Time," *IEEE International Conference in Biomedical and Health Informatics*, Orlando, Florida, USA, February 2017, pp. 409 – 412.
4. M. Ghayoumi, M. Thafar, A. Bansal, "A Formal Approach for Multimodal Integration to Derive Emotions," *Journal of Visual Languages and Sentient Systems,* Vol. 2, December 2016, pp. 48-54.
5. A. K. Bansal, "Incorporating Fault Tolerance in Distributed Agent Based Systems by Simulating Biocomputing Model of Stress Pathways," SPIE Defense and Security Symposium, April 2006, Orlando, Florida, pp. Vol. 6201, pp. 620108-01 – 62010810

6. A. Guercio, B. Simoes, and A. K. Bansal, "Towards Large Scale Voice Activated Dynamic and Interactive Internet Based Animation AND Modeling," *Proceedings of the IASTED International Conf. on Software Engineering and Applications,* Cambridge, Massachussets, 2004, pp. 749-754.
7. S. Ryan and A. K. Bansal, "A Scalable Distributed Multimedia Knowledge Retrieval System on a Cluster of Heterogeneous Architectures over the Internet," *The Intl Journal for Tools with Artificial Intelligence*, (2000), 9:3, 343-367.
8. A. K. Bansal and P. Bork, "Applying Logic Programming to Derive Novel Functional Information in Microbial Genomes," *Proceedings of the First International Workshop on Practical Aspects of Declarative Languages, Lecture Notes Series of Springer Verlag*, (1999), LNAI 1551, 274 – 289.
9. A. K. Bansal, K. Rammohanarao, A. Rao, "A Distributed Storage Scheme for Replicated Beliefs to Facilitate Recovery in Distributed System of Cooperating Agents," *Fourth International AAAI Workshop on Agent Theory, Architecture, and Languages*, *Lecture Notes in Springer Verlag Series,* (1998), LNAI 1365, 77 – 92.
10. J. Potter, J. Baker, A. K. Bansal, S. Scott, C. Ashtagiri, "Associative Model of Computing," *IEEE Computer Journal* , Vol. 27, No. 11, 1994, 19 – 25.

Graduate Students Supervision

Graduated *four* PhD students and *sixteen* MS students in artificial intelligence; Knowledge Representation, data mining of genomic data; machine learning tools for healthcare; multimedia systems and languages, speech analysis, social robotics

Textbooks

- **Arvind K. Bansal**, *Introduction to Programming Languages*, ISBN-13: 978-146-6565142, CRC Press, Dec. 2013, **sole author,** a textbook for junior level core course
- **Arvind K. Bansal**, Javed I. Khan, and S. Kaisar Alam, *Computational Health Informatics,* ISBN 13: 978-149-8756631, CRC Press, January 2020, **Principal author,** a graduate (MS) level text-book**.**

Relevant Graduate Courses Taught

1) CS 54201 — Artificial Intelligence; 2) CS 64201 —Advanced Artificial Intelligence; 3) CS 63306 — Computational Health Informatics; 4) CS 64402 - Biometrics and Multimedia Systems; 5) CS63306 - Embedded Computing

Synergistic Activities

- 1991-2019 Program Committees/session chair of more than ***eighty*** international conferences
- 1988-2019 Referee for ***100+*** international conferences and ***seventeen*** international journals
- 1992-2011 Editorial Board, International Journal for Tools with Artificial Intelligence
- Since 2004 Panelist and/or reviewer for National Science Foundation (NSF), National Institute of Health (NIH), NASA, European Council for Research (ECRC); Japanese fifth generation project
- 2001 General Conference Chair, Intl Conf. on Tools with Artificial Intelligence, Dallas, Texas
- 1994 Vice Program Chair, Intl Conf. on Tools with Artificial Intelligence, New Orleans, USA
- Multiple years of program development and policy development experience as curriculum coordinator and graduate committee member in the department.

Michael Carl

Full Professor (Computer Science and Languages)

Director - Center for Research and Innovation in Translation and Translation Technology

Department of Modern and Classical Languages

Kent State University, Kent, OH 44242

Phone: +1 330 983 3352 ; **Email:** mcarl6@kent.edu

Education

2001 Ph.D. in Computer Sciences, Universität des Saarlandes, Saarbrücken, Germany.
Dissertation title: *Example-based Decomposition, Generalisation and Refinement for Machine Translation*

1993 M.A. Sciences of Communication and Foundations of Language and Music, TU, Berlin, Germany.

1991 DEA en Intelligence Artificielle, Reconnaissance des formes et Applications, Université Paris Jussieu, Paris, France. (M. Sc. Artificial Intelligence, Pattern Recognition and Applications)

1990 M.A. (Computational Linguistics), Université Paris Jussieu, Denis-Diderot (Paris 7), Paris, France

1989 B.A. Computational Linguistics, Université Paris Jussieu, Denis-Diderot (Paris 7), Paris, France

Experience (Post-doctoral)

since Aug. 2018	Full Professor, Computer Sciences and Modern & Classical Language Studies, Kent State Uni., USA
2017 – 18	Full Professor, School of Foreign Languages, Renmin University of China, Beijing, China.
2013 – 17	Professor mso. (with special obligations), Copenhagen Business School, Copenhagen, Denmark
2008 – 13	Associate Professor, Copenhagen Business School, Copenhagen, Copenhagen, Denmark
1994 – 2008	Researcher at the Institut für Angewandte Informationsforschung (IAI), Saarbrücken, Germany
Jan-Dec.. 2002	Postdoc (Statistical Machine Translation), RALI, Université de Montreal, Québec, Canada

Research Grants and Projects (multimillion Euro/British Pounds funding as PI)

- Impetus, Co-PI, 2019-2021.
- Memento, Principal Investigator, Macau, MYRG, 2018 – 2020
- CASMACAT, Principal Investigator, EU-FP7, 2011 – 2014
- International network program, project manager and coordinator, Denmark, 2011 – 2013
- Eye-to-IT, Researcher, EU-FP6, Denmark, 2008 – 2009
- METIS-II, Principal Investigator, EU-FP6, Germany, 2004 – 2007
- Gendercheck, Project manager, University of the Saarland, 2003
- Uni-Deutsch, Researcher, BMBF, Germany, 2001 – 2003

Patent: *Translation Method and Computer Programme for Assisting the Same*, Patent No. WO/2013/083132, dk,

Industrial Products

In my work at the Institut für Angewandte Informationsforschung (IAI) between 1994 and 2008, I was involved in the conceptual design and implementation of IAI's software products and a number of applied research projects. I have developed a shallow, rule-based parser, an example-based MT system and an abductive terminology processor:

- CLAT (Controlled Language Authoring Technology) is an industrial product designed to help technical authors for controlled authoring and controlled language checking. It is in use at BMW AG, DaimlerChrysler, Siemens and others.
- DUDEN: a grammar checking tool for German in co-operation with DUDEN. More than 100.000 software copies have been sold at the end of 2008.
- AUTINDEX: is a system which automatically indexes and classifies documents. The approach is based on a controlled vocabulary and shallow natural language processing technologies.

Recent Selected Peer-reviewed Publications (Total: 150+)

1. Carl, Michael; María Cristina Toledo Báez. "Machine Translation Errors and the Translation Process: A Study across Different Languages," In: *Journal of Specialised Translation*, No. 31, 1.2019, p. 107-132)
2. Carl, Michael, Moritz Schaeffer, "The Development of the TPR-DB as a Grounded Theory Method. *Translation,*" *Cognition & Behaviour* 1:1, 2018, pp 168-193.
3. Carl; Michael, Moritz Schaeffer, "Why Translation Is Difficult: A Corpus-based Study of Non-literality in Post-editing and From-scratch Translation," *Hermes*, 56, 2017, pp 43-57.
4. Carl; Michael, Moritz Schaeffer, "Measuring Translation Literality," In: Arnt Lykke Jakobsen; Bartolomé Mesa-Lao (eds.) *Translation in Transition: Between Cognition, Computing and Technology*, (Benjamins Translation Library, Vol. 133), John Benjamins Publishing Company, Amsterdam, 2017, pp 82-106.
5. Carl, Michael, Moritz Schaeffer, M. J., "Models of the Translation Process," In J. W. Schwieter, and A. Ferreira (eds.) *The Handbook of Translation and* Cognition. *Hoboken*, NJ: Wiley-Blackwell, 2017, pp 50-70.
6. Schaeffer; Moritz, Michael Carl. (2017) A Minimal Cognitive Model for Translating and Post-editing In: Sadao Kurohashi; Pascale Fung (eds.) *Proceedings of MT Summit XV*I: Vol.1 Research Track. Nagoya: International Association for Machine Translation 2017, pp 144-155.
7. Carl, Michael, Srinivas Bangalore, Moritz Schaeffer, "Computational Linguistics and Translation Studies: Methods and Models," In: Yves Gambier; Luc van Doorslaer (eds.) *Border Crossings: Translation Studies and Other Disciplines*. Amsterdam: John Benjamins Publishing Company, 2016, pp. 225-244.
8. Alabau, Vicente, Michael Carl, Francisco Casacuberta, Mercedes Garcia Martinez, Jésus González-Rubio, Bartolomé Mesa-Lao, Daniel Ortíz-Martínez, Moritz Schaeffer, Germán Sanchis-Trilles, "Learning Advanced Post-editing," In: Michael Carl, Srinivas Bangalore, Moritz Schaeffer (eds.) *New Directions in Empirical Translation Process Research: Exploring the CRITT TPR-DB*. Cham: Springer, 2016, pp 95-110.
9. Bangalore, Srinivas, Bergljot Behrens, Michael Carl, Maheshwar Ghankot, Arndt Heilmann, Jean Nitzke, Moritz Schaeffer, Annegret Sturm (2016) Syntactic Variance and Priming Effects in Translation. In: Michael Carl, Srinivas Bangalore, Moritz Schaeffer (eds.) *New Directions in Empirical Translation Process Research: Exploring the CRITT TPR-DB*. Cham: Springer, 2016, pp. 211-238.
10. Daems, Joke, Michael Carl, Sonia Vandepitte, Robert Hartsuiker, Lieve Macken, "The Effectiveness of Consulting External Resources During Translation and Post-editing of General Text," In: Michael Carl, Srinivas Bangalore, Moritz Schaeffer (eds.) *New Directions in Empirical Translation Process Research: Exploring the CRITT TPR-DB*. Cham: Springer, 2016, pp 111-133.
11. Carl, Michael, Silke Gutermuth and Silvia Hansen-Schirra (2015) Post-editing Machine Translation: A Usability Test for Professional Translation Settings. In: Aline Ferreira, John W. Schwieter (eds.) *Psycholinguistic and Cognitive Inquiries into Translation and Interpreting*. Amsterdam: John Benjamins Publishing Company, 2015, pp 145–174.

Graduate Students Supervision

- Guided eight PhD students and several MAs in the areas of speech recognition, machine translation, empirical methods for cognitive translation studies

Relevant Courses Taught

1) Introduction to Machine Translation (1998-2005); Terminology Extraction and Maintenance; 3) Cognitive Translation Studies; 4) Empirical Methods for Cognitive Translation Studies; 5) Behavioral Data and Data Analytics; 6) Human-computer Interaction in Translation

Synergistic Activities

- Organized eight international workshops and participated in numerous research panels
- Visiting Scholar at Stanford University (Fall 2009); National Institute of Informatics, Tokyo (2015-16); University of Nantes, France (summer 2017).
- Maintain and update CRITT database (https://sites.google.com/site/centretranslationinnovation/tpr-db)

Qiang Guan, PhD

Assistant Professor (Computer Science)
Director — Green Ubiquitous Autonomous Networking Systems Laboratory
Phone: +1 330 672 2191; **Email:** qguan@kent.edu
Website: http://www.cs.kent.edu/~qguan/

Education

2005 B. S., Communication Engineering, Northeastern University, Shenyang, China
2008 M. S., Information Engineering, Myongji University, Seoul, South Korea
2014 Ph. D., Computer Science and Engineering, University of North Texas, Denton, Texas, USA

Experience

2018- present	Assistant Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2018-present	Guest Scientist, Data Science at Scale, Los Alamos National Laboratory, Los Almos, NM, USA
2015-2017,	Scientist, Data Science at Scale, Los Alamos National Laboratory , Los Almos, NM, USA
2014-15	Post-doc researcher (High Performance Computing), Los Alamos National Laboratory, NM, USA

Selected Publications

1. Chen J, Guan Q, Lian X, Bryant P, Grubel P, McPherson A, Lo L, Randles T, Chen Z. (2018). Build and Execution Environment (BEE): An Encapsulated Environment Enabling HPC Applications Running Everywhere, IEEE Bigdata. Seattle.
2. Chen X, Guan Q, Lo L, Su S, Ren Z, Ahrens J and Estrada T. (2018). In situ TensorView: In situ Visualization of Convolutional Neural Networks. IEEE Bigdata. Seattle.
3. Chen J, Guan Q, Zhang Z, Lian X, Zhang Z, Vernon L, McPherson A, Lo L, Grubel P, Ahrens J. (2018). BeeFlow: A Workflow Management System for in situ Processing Across HPC and Cloud Systems. ICDCS.
4. Guan Q, DeBardeleben N, Wu P, Eidenbenz S, Blanchard S, Monroe L, Baseman E, Tan L. (2016). Design, Use, and Evaluation of P-FSEFI: A Parallel Soft Error Fault Injection Framework for Emulating Soft Errors in Parallel Applications, Proceeding of EAI International Conference on Simulation Tools and Techniques (SIMUTOOLS).
5. Wu P, Guan Q, DeBardeleben N, Blanchard S, Tao D, Liang X, Chen J, Chen Z. (2016) Towards Practical Algorithm Based Fault Tolerance in Dense Linear Algebra". Proceeding of High Performance and Parallel and Distributed Computing (HPDC). Japan.
6. Huang S, Fu S, Debardeleben N, Guan Q, Xu C. (2015). Differentiated Failure Remediation with Action Selection for Resilient Computing", Proceeding of the IEEE Pacific Rim International Symposium on Dependable Computing. China.
7. Guan Q, DeBardeleben N, Atkinson B, Robey R, Jones W. (2015). Towards Building Resilience Scientific Applications: Resilience Analysis on the Impact of Soft Error and Transient Error Tolerance with CLAMR Hydrodynamics Mini-App", Proceeding of IEEE Cluster.
8. Guan Q, Fu S, DeBardeleben N, Blanchard S. (2014). F-SEFI: A Fine-Grained Soft Error Fault Injection Tool for Profiling Application Vulnerability. Proceeding of IEEE International Parallel & Distributed Processing Symposium, Phoenix, AZ.
9. Guan Q, Song Fu,"Adaptive Anomaly Identification by Exploring Metric Subspace in Cloud Computing Infrastructures", Proceeding of IEEE International Symposium on Reliable Distributed Systems (SRDS). Portugal.

10. Fang B, Guan Q, DeBardeleben N, Pattabiraman K, Ripeanu M. (2017). LetGo: A Lightweight Continuous Framework for HPC Applications Under Failures. Proceeding of High Performance and Parallel and Distributed Computing (HPDC), Washington D.C.

Research Grants

2018.8-2021.7, Los Alamos National Laboratory, subcontract, $48K, PFSEFI: Parallel Fault Injector, Single PI.
2019.6-2019.12, Kent State University RACAF, $4K, Smart translation for multi-culture pupulations, Co-PI

Relevant Graduate Courses Taught

1) Advanced Database Systems Design; 2) Quantum Computing (special topic); 3) Cloud Infrastructure (special topic)

Synergistic Activities

- Course development: develop the new course of cloud infrastructure.

Research Directed and Research Significance

Paul Bryant, MS, 2018, Experimental BEE for HPC and cloud infrastructure.

Ruoming Jin, PhD

Full Professor (Computer Science)

Phone: +1 330 672 9107; **Email:** rjin1@kent.edu

Website: http://www.cs.kent.edu/~jin/

Research Interests and Contributions

Data Minining; graph databases; complex information network analysis; biomedical informatics; cloud computing; Deep learning

Education

Aug. 1996	B.E. (Computer Engineering), Beihang University, Beijing, China.
Feb. 1999	M.E. (Computer Engineering), Beihang University, Beijing, China.
Aug. 2001	M. S. (Computer Science), University of Delaware, Newark, DE, USA.
Aug. 2005	PhD (Computer Science), Ohio State University, Columbus, OH, USA.

Professional Experience

2019 onwards	**Full Professor**, Department of Computer Sciences, Kent State University, Kent, Ohio, USA
2011- 19	**Associate Professor**, Department of Computer Sciences, Kent State University, Kent, Ohio, USA
2012-16	**Founded a Startup Company** based upon my research, on leave from the university **Company name:** GraphSQL now TigerGraph
2005 - 11	**Assistant Professor**, Department of Computer Sciences, Kent State University, Kent, Ohio, USA
Summer 2011	Visiting Researcher, Microsoft Research, Asia

Five Products Most Relevant to this Proposal (90+ Publications)

1. Han Hu, NhatHai Phan, Xinyue Ye, Ruoming Jin, Kele Ding, Dejing Dou, and Huy T. Vo. "DrugTracker: A Community-focused Drug Abuse Monitoring and Supporting System using Social Media and Geospatial Data." In *International Conference on Advances in Geographic Information Systems 2019 (ACM SIGSPATIAL'19)*, Nov 5-8, 2019, Chicago.
2. Jiaxiang Ren, Yang Zhou, Ruoming Jin, Zijie Zhang, Dejing Dou, and Pengwei Wang. Adversarial Learning Based Network Alignment with Reinforcement Learning. accepted at *ICDM'19*.
3. Yang Zhou, Sixing Wu, Chao Jiang, Zijie Zhang, Dejing Dou, Ruoming Jin, Pengwei Wang: Density-adaptive Local Edge Representation Learning with Generative Adversarial Network Multi-label Edge Classification, at *ICDM* 2018.
4. Yelong Shen, NhatHai Phan, Xiao Xiao, Ruoming Jin, Junfeng Sun, Brigitte Piniewski, David Kil, and Dejing Dou: Dynamic socialized Gaussian process models for human behavior prediction in a health social network, *Knowl. Inf. Syst.* 49(2): 455-479 (2016).
5. Yubao Wu, Ruoming Jin, Xiang Zhang: Efficient and Exact Local Search for Random Walk Based Top-K Proximity Query in Large Graphs. *IEEE Trans. Knowl. Data Eng.* 28(5): 1160-1174 (2016).

Five Other Products

6. Hao Wei, Jeffrey Xu Yu, Can Lu, Ruoming Jin: Reachability querying: an independent permutation labeling approach. *VLDB J.* 27(1): 1-26 (2018).
7. Yubao Wu, Ruoming Jin, Jing Li, Xiang Zhang: Robust Local Community Detection: On Free Rider Effect and Its Elimination. *PVLDB* 8(7): 798-809 (2015).
8. Yubao Wu, Ruoming Jin, Xiang Zhang: Fast and unified local search for random walk based k-nearest-neighbor query in large graphs. *SIGMOD*, 2014.
9. Ruoming Jin, Guan Wang: Simple, Fast, and Scalable Reachability Oracle. *PVLDB* 6(14): 1978-1989 (2013).

10. Ruoming Jin, Anjan Goswami, and Gagan Agrawal, Fast and Exact Out-of-Core and Distributed K-Means Clustering, in *Knowledge and Information System (KAIS journal*), 10(1): 17-40 (2006)

Major Extramural Research Grants

2019- 24 Northeast Ohio Tri-County Prevention Infrastructure, Substance Abuse and Mental Health Services Administration, SAMHSA, $1.5M, co-PI

2014-19 IBSS: Spatiotemporal Modeling of Human Dynamics Across Social Media and Social Networks , NSF-1416509, $999,887, co-PI

2013-16 Understanding the Mechanism of Social Network Influence in Health Outcomes Through Multidimensional and Semantic Data Mining Approaches, NIH R01 GM103309-01A, in collaborating with University of Oregon, UNC Charlotte, and PeaceHealth Lab, $1.54M, co-PI, Subaward PI at KSU

2010-15 NSF CAREER Award (Novel Data Mining Technologies for Complex Network Analysis); sole PI

2007-08 OBR Research Challenge Award; sole PI

Software and Startup Activity

- Commercial Graph Database (Tigergraph, tigergraph.com), Ruoming Jin, co-development (2012-2016), used by Alipay and Visa among others in production system.

Graduate Students Supervision

- Supervised five PhD dissertations and eight MS theses to completion. Students placed in multinationals like Google and Lockheed Martin.
- Supervised postdoc students

Relevant Graduate Courses Taught

1) Introduction to Machine Learning and Deep Learning; 2) Data Mining Techniques; 3) Big Data Analytics; 4) Deep Learning for Recommendation System (special topic); 5tatistical Foundations of AI and Data Science (special topic); 5) Graph mining and management; 6) Advanced Database Systems Design; 7) Advance Computing Platforms for Data Analysis' 8) database Systems Design

Synergistic Activities

1. Editorial Board Members, Knowledge and Data Engineering (KDE) Journal, 2018-
2. Associate Editor, IEEE Transactions on Knowledge and Data Engineering (TKDE) 2013- 2015.
3. Review Board of PVLDB, 2019, 2014, 2013, 2012
4. (Senior) Program Committee Member for conferences of several professional societies, most recently including AAAI'20, AAAI'19, KDD'19, ICDM'19, CIKM'19
5. Workshop Co-chair for the International Workshop on Mining Multiple Information Sources (MMIS), in conjunction with KDD'07, KDD'08, **ICDM'09 and ICDM'10**

Javed I. Khan, PhD

Full Professor and Chairperson (Computer Science)
Director — Perceptual Engineering and Media Net Laboratories
Phone: +1 330 672 9038**; Email**: Javed@kent.edu
Website: http://www.cs.kent.edu/~javed

Education

1987	B. Sc., Electrical & Electronics Engg., Bangladesh Univ. of Engg. & Technology (BUET), Dhaka, Bangladesh
1990	M. S. (Electrical Engg. In Computer Track), University of Hawaii at Manoa (UHM), Manoa, Hawaii, USA
1995	Ph. D. (Electrical Engg. In Computer Track), University of Hawaii at Manoa (UHM), Manoa, Hawaii, USA

Experience

2018-now	Advisor, World Bank, Global R&E Advanced Optical Net
2012-present	Professor and Chairperson, Dept. of Computer Science, Kent State University, Kent, Ohio, USA
2005-now	Fulbright Senior Specialist, US National Roster of Experts
2006-12	Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2006-10	Advisor, World Bank, Global R&E Advanced Optical Net
2002-06	Associate Professor, Department of Computer Science, Kent State, Kent, Ohio, USA
1997-2002	Assistant Professor: Dept. of Computer Science, Kent State, Kent, Ohio, USA
1995-97	Post-doctoral Fellow, Open Grants, East West Center of Hawaii, USA.

Five Most Related Publications (Total: 100+ first authored refereed publications)

1. N. S. A. Madi and J. I. Khan, “Modeling Part-Of-Speech and Semantic-Significance Effects on Semantic Construction During Reading”. 2019 IEEE 13th International Conference on Semantic Computing, Jan 30 - Feb 1, 2019, Newport Beach, California, DOI: 10.1109/ICOSC.2019.8665565.
2. N. S. A. Madi and J. I. Khan, "Constructing Semantic Networks of Comprehension from Eye-movement During Reading," 2018 IEEE 12th International Conference on Semantic Computing, Jan 31, 2018 in Laguna Hills.
3. A. Babour, F, Nafa, and J. I. Khan. “Connecting the Dots in a Concept Space by Iterative Reading of Free text References with Wordnet”, IEEE/WIC/ACM Web Intelligence Conference 2015, December 6-9, 2015. Singapore. ISSN: 2308-4065, ISBN: 978-1-61208-437-4. Pp-66-73.
4. F, Nafa, J. I. Khan, S. Othman, and A. Babour. “Deepening Prose Comprehension by Incremental Knowledge Augmentation”, INTELLI 2016. The Fifth International Conference on Intelligent Systems and Applications, November 13 -17, 2016 in Barcelona, Spain. pp.108 to 114, ISSN: 2308-4065, ISBN: 978-1-61208-518-0
5. Javed I. Khan & Manas S. Hardas , Does Sequence of Presentation Matter in Reading Comprehension? A Model Based Analysis of Semantic Concept Network Growth during Reading, Proceedings of the Seventh IEEE International Conference on Semantic Computing, IEEE ICSC 2013, September 2013, Irvine, California, USA.

Five Other Significant Publications

6. IEEE Standards Track: *IEEE Vision for Smart Grid Communications: 2030 and Beyond*, Chapter 4, “*Smart Grid Communications Technologies*” Javed I. Khan (Lead Author), Kent State University, Andrea M. Tonello, University of Udine, Lorenzo Vangelista, University of Padova, Lutz Lampe, University of British Columbia, Andreas Maeder, NEC Laboratories Europe, Tim Godfrey, Electric Power Research Institute, & Shantidev Mohanty, Intel Corporation., in pp., Edited by: Dr. Sanjay Goel, Stephen F. Bush and David Bakken, Print ISBN: 978-0-7381-8460-9, Publisher IEEE Standards, May 2013, URL: IEEE Explorer
7. Naser Al Madi, Javed I. Khan. "Is Learning by Reading a Book Better Than Watching a Movie? A Computational Analysis of Semantic Concept Network Growth During Text and Multimedia Comprehension." In *Proceedings of the 2015 IEEE International Joint Conference on Neural Networks*, IJCNN 2015, pp1-8, Killerny, Ireland, July 2015.

8. Oleg V. Komogortsev, and Javed I. Khan, Eye Movement Prediction by Oculomotor Plant Kalman Filter with Brainstem Control, *Journal of Control Theory and Applications*, Springer Publications, Volume 7. Number 1, February 2009, pp-14-22.
9. Oleg Komogortsev & Javed I. Khan, Predictive Compression for Real Time Multimedia Communication Using Eye Movement Analysis, *ACM Transactions on Multimedia Computing, Communications, and Applications,* TOMCCAP, Volume 4, Issue 3, August 2008, October 2007.
10. Khan Javed. I. & D. Yun, Characteristics of Holographic Associative Memory in Retrieval with Localizable Attention, *IEEE Transactions on Neural Networks*, Vol-9, Issue-7, May '98, p.389-406. (GS(6))

Extramural Research Grants

- Research funded by various agencies including US Defense Advanced Research Project Agency (DARPA), National Science Foundation (NSF), NASA, Air-Force (AFRL), World Bank, and the State of Ohio for multimillion dollars.
- NASA Fellow for space Internet

PhD Dissertations and MS Theses Supervision

- Supervised to completion twelve PhD dissertations and 13 Master's theses in the areas of human comprehension and conscious learning, Knowledge modeling, eye-tracking based perception, multimedia networking and perception, multimedia information retrieval, medical image transfer, and advanced networking protocols.

Books

- Arvind Bansal, **Javed Khan**, S. Kaisar Alam, *Computational Health Informatics*, Textbook (graduate-level), ISBN 13: 978-149-8756631, CRC Press, to appear, January 2020, in press.
- Guest Editor Foundations of peer-to-peer systems, Journal of Computer Communications, Volume 31, Issue 2, 5 February 2008, Pages 187-189.
- Guest Editor: Disruptive networking with peer-to-peer systems, Journal of Computer Communications, Volume 31, Issue 3, 25 February 2008, Pages 419-422.
- Guest Editor: Computer Communications, Volume 28, Issue 6, Pages 589-711 (15 April 2005)

Relevant Graduate Courses Taught

1) Artificial Intelligence; 2) Computer Communication Network; 3) Internet Engineering

Synergistic Activities and Research Significance

- Javed's research lab specializes in modeling of complex systems including human comprehension and conscious learning. He is also expert on cross-layer advanced networking.
- Associate editor of Elsevier *Journal of Network and Computer Applications* (JNCA).
- Advisor to World Banks's HEAT: Higher Education Higher Education Acceleration and Transformation (HEAT)
- Master planner/ designer of two national high speed advanced network infrastructures- BdREN -the national REN of Bangladesh, and NgREN -the national REN of Nigeria. BdREN- a nationwide high-speed network built on owned dark fiber to connect 100+ public and private universities, medical colleges and research institutions
- Since 2005 he serves in the **Fulbright National Roster of US Experts** as one of the program's highest impact expert. In his latest 3rd Senior Specialist assignment (2017) in invitation of the telecommunication regulatory authority of the government of Malaysia (MCMC) - led the preparedness review for future networking (5G, , IoT, Cloud and Network Virtualization).

Jong-Hoon Kim, Ph.D.

Assistant Professor (Computer Science)

Director — Advanced Telerobotics Research Laboratory

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Website: http://www.atr.cs.kent.edu/people/jong-hoon_kim/

Education

2005 B.S., Computer Science and Engineering, Seoul National University of Science and Technology, Seoul, South Korea

2008 M.S., Computer Science, Louisiana State University, Baton Rouge, LA USA

2011 Ph.D., Computer Science, Louisiana State University, Baton Rouge, LA USA

Experience

Jan. 2017 – Present Assistant Professor, Department of Computer Science, Kent State University

Aug. 2014 – Dec. 2016 Chief Technology Advisor, ArtXpresso L.L.C., South Korea

Jan. 2012 – Aug. 2014 Assistant Professor and Director of Discovery Lab, SCIS, Florida International Univ., FL, USA

Aug. 2006 – Dec. 2011 Research Assistant, Louisiana State University

Selected Publications

1. Gokarna Sharma, Pavan Poudel, Ayan Dutta, Vala Zeinali, Tala Talaei Khoei, and Jong-Hoon Kim, "A 2-Approximation Algorithm for the Online Tethered Coverage Problem", *International Conference on Robotics - Science and Systems*, Freiburg im Breisgau, Germany, June 22-26, 2019.
2. Gokarna Sharma, *Ayan Dutta , Tala Talaei Khoei, Pavan Poudel, and Jong-Hoon Kim, "Optimal Online Coverage Path Planning with Energy Constraints", *International Conference on Autonomous Agents and Multi Agent Systems*, Montreal, Canada, May 13 - 17, 2019.
3. Irvin Cardenas, Kelsey Vitullo, Michelle Park,*Jong-Hoon Kim, Margarita Benitez, Chanjuan Chen, and Linda Ohrn-McDaniels, "Telesuit: An Immersive User-Centric Telepresence Control Suit", *The ACM/IEEE International Conference on Human-Robot Interaction*, Deagu, S. Korea, Mar 11-14, 2019.
4. Irvin Steve Cardenas and Jong-Hoon Kim, "Robot-Human Agreements and Financial Transaction Enabled by a Blockchain and Smart Contracts", *The 13th Annual ACM/IEEE International Conference on Human Robot Interaction* (*HRI-18*), March 58, 2018, Chicago, IL, USA.
5. Jong-Hoon Kim, Hae Yean Park, Hye-Min Kang, and *YoungJin Jung, "Frequency Feature for Proportional Myoelectric Control of Robotic Rehabilitation Therapy," *The Journal of Korean Society of Assistive Technology*, Vol. 9, No. 1, September 30, 2017.

Other Publications

6. Irvin S. Cardenas, HyunJae Jeong**,** Jong-Hoon Kim, and Yongseok Chi "Unique Cipher-acoustic Languages for Human-Robot Interactions", *The ACM/IEEE International Conference on Human- Robot Interaction*, Deagu, South Korea, March 11 - 14, 2019.
7. Do Yeon Kim, Irvin Steve Cardenas, and Jong-Hoon Kim, "Engage/Disengage: Control Triggers for Immersive Telepresence Robots", *The ACM/IEEE International Conference Human-Agent Interaction*, HAI '17, October 17-20, 2017, Bielefeld, Germany

8. Jong-Hoon Kim, Nagarajan Prabakar, Gokarna Sharma and S. Sitharama Iyengar, "Inspiring Innovative Aspirations among Undergraduate Students using Self-Motivated Project-Based Learning", *The 8th Annual International Conference on Computer Science Education: Innovation and Technology* (*CSEIT 2017*), October 9-10, 2017, Singapore.
9. Sarra Berrahal, Jong-Hoon Kim, Slim Rekhis, Noureddine Boudriga, Deon Wilkinsu, and Jaime Acevedou, "Border surveillance monitoring using Quadcopter UAV-Aided Wireless Sensor Networks", *Journal of Communications Software and Systems* (*JCOMSS*), ISSN: 1845-6421, VOL. 12, NO. 1 (p67-p82), March 29, 2016.
10. Jong-Hoon Kim, Gokarna Sharma, Noureddine Boudriga, S.S. Iyengar and Nagarajan Prabakar, "Autonomous Pipeline Monitoring and Maintenance System: An RFID-based Approach", *EURASIP Journal on Wireless Communications and Networking*, December 21, 2015.

Research Grant

- Co-PI, Healthy Community Research (2018-19), Project: Using Virtual Reality to Identify Health Promoting Physical Activity Factors among Individuals with Intellectual and Developmental Disabilities, PI: Mary Ann Devine.

Relevant Graduate Courses Taught

1) Advanced Human-Robot Interaction; 2) Software Development for Robotics; 3) Human-Robot Interaction;

Synergistic Activities

- Conducted Robotics Summer Camps for high school students
- Served as an executive editor at Springer Blockchain Technology Book Series
- Served as a research mentor at Research Experience for Undergraduates (REU) NSF Program
- Served as a program organizer at Research Experience for International Undergraduates (REIU) Program
- Selected as a reviewer for several international journals and conferences, most recently including International Journal of Intelligent Computing and Cybernetics (IJICC)

Research Directed and Awards

- 2019 Ethereum Denver Award (Irvin Cardenas, Ph.D. Student)
    - Netus Foundation received the POA Network award for best decentralized application developed on an Ethereum-based network
- 2019 Ethereum New York Award (Irvin Cardenas, Ph.D. Student)
    - Best Decentralized Application and Best Integration Award by ThunderCore for developing the first blockchain-based robotic game on ThunderCore
- 2019 ATR Lab won 2nd place at KSU Line-Following Robot Competition (Jared Butcher, Kody Richardson, Nadia Camacho Cabrera - Undergraduates)
- 2018 Great Minds in STEM Award (Irvin Cardenas, Ph.D. Student)
    - HENAAC and Oracle Software awards the title of Great Minds in STEM to a select number of students that demonstrate outstanding research and academic excellence.
- 2017 ATR Lab won the third prices ($500) at the SkyHack-17 Competition (Chaisay Nicholas Letdara and Brian Selle - Undergraduates) - Winning title: ImmersiFLY, and then extended their idea to a research publication

Jung Yoon Kim

Assistant Professor (Computer Science)
Director — Digital Systems Laboratory
Phone: +1 330 672 9064; **Email:** jkim78@kent.edu
Website: https://www.kent.edu/cs/jungyoon-kim

Research Interest and Contributions

Smart and Connected Sensors, Embedded Systems, *Internet of Things (IoT), and Data Analytics.*

Education

2004 B. E., Electrical & Computer Engineering, University of Ulsan, South Korea
2006 M. S., Electrical & Computer Engineering, University of Ulsan, South Korea
2014 Ph. D., Information Sciences and Technology, The Pennsylvania State Univ., State Park, PA, USA

Experience

2019 –	Assistant Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2017-18	Research Professor, Ulsan National Institute of Science and Technology,
2015-17	Postdoc-fellow (Smart and Connected Health), University of Michigan, Ann Arbor, Michigan, USA
2013-15	Postdoc fellow (Internet of Things), Singapore Management University, Singapore

Selected Research Publications

1. J.Y. Kim, H. ElMoaqet, D. M. Tilbury and S-K. Ramachandran, "Time domain characterization for sleep apnea in oronasal airflow signal: a dynamic threshold classification approach," *Physiological Measurement, 2019,* Vol. 40, Num. 5.
2. S. Cheon, J.Y. Kim, J. Lim, "The Use of Deep Learning to Predict Stroke Patient Mortality," *Int. J. Environ. Res. Public Health, 2019, 16(11), 1876.*
3. O. V. Bitkina, J.Y. Kim, J.W. Park J.H. Park and H.K. Kim, "Identifying Traffic Context using Driving Stress: A Longitudinal Preliminary Case Study", *Sensors* 2019*, 19, 2152.*
4. J. Lim, J.Y. Kim, S. Cheon, "A Deep Neural Network-Based Method for Early Detection of Osteoarthritis Using Statistical Data," *Int. J. Environ. Res. Public Health.* 2019, 16, 1281.
5. S. D. Kwon, J.Y. Kim and C.H. Chu, "Real-time Heart Attack Detection Using an Embedded Microcontroller in a Pervasive Environment", *Electronics*. 2018, 7, no. 6: 88. (Corresponding Author)
6. J.Y. Kim, N. Liu, H.X. Tan, and C.H. Chu, "Unobtrusive Monitoring to detect Depression for Elderly with Chronic Illnesses," *IEEE Sensors Journal.* Vol. 17, Issue: 17, 2017, pp. 5694- 5704. (Corresponding Author)
7. S. Zhou, C.H. Chu, Z. Yu and J.Y. Kim, "A Context-aware Reminder System for Elders Based on Fuzzy Linguistic Approach*," Expert Systems with Applications*, Vol. 39, No. 10, 2012,pp. 9411-9419.
8. J.W. Park, J.Y. Kim, J.H. Park, A. Sheta, C. Murphey, D. Um, "Development of a Sleep Monitoring System by using a Depth Sensor: A Pilot Study" 10th International Conference on Applied Human Factors and Ergonomics (AHFE), Washington D.C., USA, July 24-28, 2019.
9. X. Wu, L. Cheng, C.H. Chu, J.Y. Kim, "Using Deep Learning and Smartphone for Automatic Fall Detection" *The 7th International Conference for Smart Health* (ICSH '19), Shenzhen, Guangdong, China, July 1-2, 2019.
10. J.Y. Kim, H. ElMoaqet, D. M. Tilbury and S-K. Ramachandran, "A New Algorithm for the Detection of Sleep Apnea Events in Respiration Signals" *The 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (EMBS'16), Orlando, FL, USA, August 16-20, 2016. (Corresponding Author; Oral Presentation)
11. J.Y. Kim and C.H. Chu, "Unobtrusive Sensing for Sleep Quality Monitoring and Assessment" *NIH-IEEE Strategic Conference on Point of Care Technologies for Precision Medicine*, Washington, USA, November 9-10, 2015.

Research Grants

- "Sensor-Enabled Homes and Personalized Care for Senior Singaporeans Living in the HDB Environment." Land and Livability National Innovation Challenge (L2NIC) Project funded by National Research Foundation – Prime Minister's Office - Singapore (**SGD 3 Million for 3 years**), Aug. 2014 – Jul. 2016. (***Key Research Staff***: Generating Core Research Idea and Technical Consultant) – 1st Winner among the 78 proposals

Research Significance

- Most of my research projects involve building energy-efficient integrated hardware/software embedded Sensing systems to enable real-time monitoring and detection using various sensors, smart objects, wearable devices, wired/wireless communication, and machine learning/deep learning/analytics technologies for emerging applications. Such as smart home (e.g., energy monitoring, elderly fall detection), medical and healthcare systems (e.g., health condition, heart disease, sleep-related breathing disorder, stress detection, and depression, etc.) and environmental monitoring (e.g., cut slope movement and air quality)

Relevant Graduate Courses Taught

(1) Embedded System Programming; 2) Advanced Digital Systems; 3) Data Analytics with Wearable and IoT Devices (special topic)

Kwangtaek Kim, Ph.D

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Research Area and Contribution

Haptics, immersive interface, virtual/augmented reality, wearable computing for touch, rehabilitative robotics, psychophysical study, rehabilitative robotics, image processing, virtual haptic palpation for imaging systems, human machine interface.

Education

2010 Ph.D., Electrical and Computer Engineering, Purdue University, West Lafayette, IN, USA

2001 Master's Degree – Electronic and Information Engineering, Korea University, Seoul, Republic of Korea

1998 Bachelor's Degree – App. Electronics Engineering, Korea University, Seoul, Republic of Korea

Experience

Aug 2019 – Present:	Assistant Professor, Dept. of Computer Science, Kent State University, Kent, OH
2015 – 2019	Associate Professor, Department of Information and Telecomm. Engineering, Incheon National University, Republic of Korea
Dec 2018 –	Visiting Professor (contract), Lab. of Images, Signals, and Intelligent Systems (LISSI), University of Paris-Est Creteil (UPEC), Paris, France
Jan. 2014 – Feb 2015	Research Professor, Dept. of Electrical and Electronic Engineering, Yonsei University, Republic of Korea
Dec 2012 – Jan 2014	Researcher (Full Time Employee), Human Computer Interaction Group, Microsoft Research Asia, Beijing, China
Nov 2011 – Nov 2012	Project Leader (Chief Researcher), CTO Seoul R&D Campus, LG Electronics Advanced Research Institute, Seoul, Republic of Korea
Oct 2010 – Aug 2011	Postdoctoral Research Associate, Physiology and Pharmacology Department, SUNY Downstate Medical Center, NYC, NY, US

Selected Publications (Total: 21+)

1. S. Yu, S. Jin, K. Kim, "Haptic soft keyboard for tablet-sized touchscreens", *Applied Sciences,* Vol. 9, No. 3080, July 2019, DOI: 10.3390/app9153080.
2. J. I. Vicente and K. Kim, "Gradient-based 3D skin roughness rendering from an in-vivo skin image for dynamic haptic palpation", *Skin Research and Technology*, DOI: 10.1111/srt.12650, 25(3), 305-317, May 2019.
3. M. Ko, D. Kim, M. Kim and *K. Kim, "Illumination insensitive skin depth estimation from a light field camera based on CGANs toward haptic palpation", *Electronics*, 7(11), 336-356, Nov 14, 2018.
4. Kwangtaek Kim, "Image based haptic roughness estimation and rendering for haptic palpation from in-vivo skin images", *Medical & Biological Engineering and Computing*, DOI: 10.1007/s11517-017-1700-4, 56(3), 413- 420, Mar 6, 2018.
5. B. Han and K. Kim, "Typing performance evaluation with multimodal soft keyboard completely integrated in commercial mobile devices", *Journal of Multimodal User Interface*, doi:10.1007/s12193-015-0177-4,Vol 9, Issue 3(2015), 173-181, Sep 24, 2015.

6. K. Kim, Joongrock Kim, Jaesung Choi, Junghyun Kim, and *Sangyoun Lee, "Depth Camera Based 3D Hand Gesture Controls with Immersive Tactile Feedback for Natural Mid-air Gesture Interactions," *Sensors*, 15, 1022- 1046.; doi:10.3390/s150101022, Jan 9, 2015.
7. K. Kim, M. Barni and H. Z. Tan, "Roughness-adaptive 3D Watermarking Based on Masking Effect of Surface Roughness", *IEEE Transactions on Information Forensics and Security*, VOL.5, NO.4, pp. 721-733, Dec 2010.
8. S. A. Cholewiak, K. Kim, H. Z. Tan, and B. D. Adelstein, "A Frequency-Domain Analysis of Haptic Gratings", *IEEE Transactions on Haptics*, VOL 3, NO 1, pp 3-14, Jan-Mar 2010.

Extramural Research Grants (Note: USD approximately converted from KRW)

1. The National Research Foundation, 2018.6~2023.5 (5 years), **Project**: Deep learning based haptic skin imaging for the diagnosis of skin diseases, Principal Investigator, amount – $234,550 ($46,910 per year) in total
2. The National Research Foundation, France-Korea International Joint Research Program: INU UPEC, 2017.5~2019.4 (2 years), **Project:** Haptic ankle foot orthosis for assistance and rehabilitation Principal Investigator, amount – $28,032 ($14,016 per year) in total Principal Investigator in France: Dr. Samer Mohammed, UPEC
3. The National Research Foundation, 2015.11~2018.10 (3 years), **Project:** Haptic skin imaging for the diagnosis of skin diseases, Principal Investigator, amount –$139,500 ($46,500 per year) in total

Relevant Graduate Courses Taught/Assigned

1) Computer Graphics; 2) Human-Computer Interaction; 3) Capstone Project (new assignment)

Synergistic Activities

- August 2013 Distinguished Teaching Award, Incheon National University, Korea.
- August2013 Spot Award, Microsoft Research, August
- May 2005 Outstanding Research Engineer, Anyang R&D Lab, LG Electronics , Korea
- Member of IEEE Computer Society and ACM
- Member, IEEE Technical Committee on Haptics (http://www.worldhaptics.org)
- Member, IEEE RAS (Robotics and Automation Society) Technical Committee on Cognitive Robotics

Xiang Lian, PhD

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Director - Big Data Science Laboratory
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Research Interests and Contributions

Uncertain and Certain Graph Databases; Spatial Crowdsourcing; Probabilistic, Inconsistent, and Uncertain Databases; Streaming Time Series, Spatio-Temporal Databases.

Education

2003	B. S., Computer Science, Nanjing University, China
2009	Ph. D., Computer Science and Engg., Hong Kong University of Science and Technology Hong Kong
2009-11	Post Doc., Computer Science and Engg., Hong Kong University of Science and Technology Hong Kong

Experience

- Assistant Professor, Kent State University, Kent, OH, USA, 09/2016 ~ present
- Assistant Professor, University of Texas Rio Grande Valley, Edinburg, TX, USA, 09/2011 ~ 08/2016
- Research Assistant Professor, HKUST Fok Ying Tung Graduate School, Hong Kong, 2010 ~ 2011

Selected Publications [Total: 75+; Google Scholar: h-index: 28; Citations: 2516]

1. Xiang Lian and Lei Chen. Reverse Skyline Search in Uncertain Databases. In *ACM Transactions on Database Systems* (TODS), 35(1), 2010.
2. Xiang Lian and Lei Chen. Shooting Top-*k* Stars in Uncertain Databases. In *Very Large Data Bases Journal* (VLDBJ), 20(6), pages 819-840, 2011.
3. Xiang Lian and Lei Chen. Probabilistic Inverse Ranking Queries in Uncertain Databases. In *Very Large Data Bases Journal* (VLDBJ), 20(1), pages 107-127, 2011.
4. Peng Cheng, Xiang Lian, Xun Jian, and Lei Chen. FROG: A Fast and Reliable Crowdsourcing Framework. In *IEEE Transactions on Knowledge and Data Engineering* (TKDE), 31(5), pages 894-908, 2019.
5. Ye Yuan, Xiang Lian, Lei Chen, Jeffery Xu Yu, Guoren Wang, and Yongjiao Sun. Keyword Search over Distributed Graphs with Compressed Signature. In *IEEE Transactions on Knowledge and Data Engineering* (TKDE), 29(6), pages 1212-1225, 2017.
6. Xiang Lian and Lei Chen. Quality-Aware Subgraph Matching Over Inconsistent Probabilistic Graph Databases. In *IEEE Transactions on Knowledge and Data Engineering* (TKDE), 28(6), pages 1560-1574, 2016.
7. Ye Yuan, Xiang Lian, Lei Chen, Yongjiao Sun, and Guoren Wang. RS*k*NN: *k*NN Search on Road Networks by Incorporating Social Influence. In *IEEE Transactions on Knowledge and Data Engineering* (TKDE), 28(6), pages 1575 - 1588, 2016.
8. Xiang Lian and Dongchul Kim. Efficient Ad-Hoc Graph Inference and Matching in Biological Databases. In *Proc. of the ACM Conference on the Management of Data* (SIGMOD'17), pages 359-373, 2017.
9. Xiang Lian and Lei Chen. Monochromatic and Bichromatic Reverse Skyline Search over Uncertain Databases. In *Proc. of the ACM Conference on the Management of Data* (SIGMOD'08), pages 213-226, 2008. ***(Citations : 257)***

10. Yufei Tao, Dimitris Papadias, and **Xiang Lian**. Reverse *k*NN Search in Arbitrary Dimensionality. In *Proc. of the Very Large Data Bases Conference* (VLDB'04), pages 744-755, 2004. **(*Citations : 335*)**

Research Grants

- Co-PI of NSF OAC grant "SI2-SSE:GeoVisuals Software: Capturing, Managing, and Utilizing GeoSpatial Multimedia Data for Collaborative Field Research," **PI:** Ye Zhao.

Graduate Students Supervision

- Directing four PhD dissertation and one MS thesis

Relevant Graduate Courses Taught

1) Data Mining Techniques; 2) Big Data Analytics; 3) Probabilistic Data Management

Synergistic Activities

- **Seminar, Conference Talks, and Tutorial:** In 2011-2019, Dr. Lian gave several seminar/conference talks/tutorials on his published papers, for example, "Efficient Ad-Hoc Graph Inference and Matching in Biological Databases", published in ACM SIGMOD 2017 conference.
- **Research Visits:** In Summer 2012-2018, Dr. Lian had numerous academic visits to world-wide universities, for example, in Summer 2017, he visited the *Hong Kong University of Science and Technology*, Hong Kong, and worked with Dr. Lei Chen on several database research problems.
- **Reviewer** for over 45 international conferences/journals,
- **Proceeding Co-chair,** *ACM Conference on the Management of Data* (SIGMOD) in 2014 and 2015
- **Proceeding Co-chair,** *International Conference on Web-Age Information Management* (WAIM) in 2016
- **Proceeding co-chair**, APWeb-WAIM 2017,
- Publicity co-chair, *International Conference on Database Systems for Advanced Applications* (DASFAA) in 2017.
- Member, Computer Science Graduate Committee, involved in departmental graduate program policies, since 2017.

1.

Cheng Chang Lu, PhD

Full Professor(Computer Science)

Director— Image Processing and Vision Laboratory

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Website: http://www.cs.kent.edu/~lucc

Education

1983	B. S. (Control Engineering), National Chiao Tung Univ., Hsinchu, Taiwan
1985	M. S. (Electrical Engineering), Southern Methodist University, Dallas, Texas, USA
1988	M. S. (Electrical Engineering), Southern Methodist University, Dallas, Texas, USA

Experience

2005 – Present	Assistant Chair, Department of Computer Science, Kent State University.
2005 – Present	Professor, Department of Computer Science, Kent State University.
2001 – 2005	Associate Professor, Department of Computer Science, Kent State University.
1993 - 2001	Associate Professor, Mathematics and Computer Science, Kent State University.
1988 - 1993	Assistant Professor, Mathematics and Computer Science, Kent State University.
1992 - 1992	Summer Faculty Fellow, Space Electronics Division, NASA Lewis Research Center.

Products Most Closely Related

1. Ferdig, R.E., Pytash, K.E., Kosko, K.W., Gandolfi, E., & Mathews, R. with Bedesem, P., Harjusola-Webb, S., Sansosti, F., Lu, C.C, Kratcoski, A., Mulvey, B., and Boyle, S. (2016). *Use and perceptions of mobile applications and technologies by those interested in special education*. Kent, OH: Kent State University.
2. Enrico Gandolfi, Richard E. Ferdig, Peña Bedesem, Cheng Chang Lu, Guest Editors, "Mobile learning and Special Education", International Journal on Interaction Design & Architecture(s) - IxD&A, July 2016.
3. Omar Alaql and Cheng Chang Lu. “Text Line Extraction for Historical Document Image using Steerable Directional Filters,” 2014 International Conference on Audio, Language and Image Processing, July 2014.
4. Mehdi Ghayoumi and Cheng Chang Lu. “Improving Exemplar based Implanting Method with a Fuzzy Approach,” 2014 International Conference on Audio, Language and Image Processing, July 2014.
5. Mingming Lu, Qiyu Zhang, Wayne Cheng, Cheng Chang Lu, “Retrieval of Multimedia Objects using Color Segmentation and Dimension Reduction Features,” International Conference on Image and Graphics, Xi’an, China, Sep 2009.

Other Significant Products

6. Yuan Zhi, Ye Zhao, Cheng Chang Lu, “Detail-Preserving Compression for Smoke Based Flow Visualization”, to appear in Journal of Visualization, Spring 2019.
7. Omar Alaql, Kambiz Ghazinour , Cheng Chang. Lu, "Classification of Image distribution for Image Quality Assessment," *2016 International Conference on Computational Science and Computational Intelligence,* Dec 2016.
8. Omar Alaql, Kambiz Ghazinour, Cheng Chang Lu “ Classification of Image Distortions Based On Features Evaluation, “ IEEE International Symposium on Multimedia, Dec 2016.

9. Omar Alaql and Cheng Chang Lu. "Text Line Extraction for Historical Document Image using Steerable Directional Filters," 2014 International Conference on Audio, Language and Image Processing, July 2014.
10. Mehdi Ghayoumi and Cheng Chang Lu. "Improving Exemplar based Implanting Method with a Fuzzy Approach," 2014 International Conference on Audio, Language and Image Processing, July 2014.

Selected Research Grants

- Co-PI, NSF Award DRL-1908159 (09/01/14-08/31/17): This grant focuses on examining how preservice teachers' professional knowledge may be facilitated by using immersive 360 video and technologically embedded scaffolds. This includes three primary goals: examining the effect of single versus multi-perspective 360 video on preservice teachers' professional knowledge; examining how PSTs use annotation technology in 360 video experiences; designing a platform for teacher educators to create and view their own 360 video immersive experiences.
- Co-PI, NSF Award DRL-1422764 (09/01/14-08/31/17): This grant focuses on the use of mobile devices for informal science learning at National Parks. The ParkApps application includes features such as Learn as You Go, Adventure Tracks and Citizen Science, and developments such as app building, mobile computing and image processing. Leverage research and teaching experience in mobile computing, image processing and database systems to establish the mobile learning environment. Closely work with the development team consisting of both undergraduate and graduate students on mobile app design, implementation, evaluation and optimization.
- Co-PI, AT&T Foundation Project (09/01/15-08/31/16): This grant focused on the use of mobile apps for special education STEM teaching and learning includes learning, development and/or refinement of research tools; computation methodologies, and algorithms for problem-solving; development of databases to support research and education; broadening the participation of groups underrepresented in STEM; and service to the scientific and engineering community outside of the individual's immediate organization.
- Co-PI, Wright Patterson Base and Airforce (2003-05), Project: Fault Tolerant Adaptive Multimedia Agent Based Systems. This project focused on self-healing fault tolerant agents that could classify and recognize objects on the grounds from an aerial camera.

Relevant Graduate Courses Taught

1) Image Processing; 2) Biological Image Processing (special topic); 3) Pattern Matching Principles

Synergistic activities

- Graduate Student Research Advisor, Department of Computer Science: Advise students on data analytics, image quality assessment and medical image registration.
- Supervised and graduated multiple PhDs and Masters in the area of image processing, medical imaging, image recognition and segmentation, biological imaging.
- Developed special topic graduate courses on biological image processing, medical imaging and machine learning.
- Collaborated with researchers in industry in medical image processing and biological image processing.

Hassan Peyravi

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Director —Computer Networks Laboratory
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Research Interest and Contribution

Network security; Media Access Control; wireless and mobile system; Switching and multiplexing; Traffic management and congestion control

Education

1983 M. S. (Computer Science), School of EECS, Oklahoma State University, Oklahoma, USA

1985 Ph. D. (Computer Science),), School of EECS, Oklahoma State University, Oklahoma, USA

Experience

2000 – Present	Full Professor, Department of Computer Science, Kent State University, Kent, Ohio
2006-2010	Graduate Program Director, Department of Computer Science, Kent State University, Kent, Ohio
1993-2000	Associate Professor, Department of Computer Science, Kent State University, Kent, Ohio
1996-99	Curriculum Coordinator, Department of Computer Science, Kent State University, Kent, Ohio
1992-95	Curriculum Coordinator, Computer Science Program, Kent State University, Kent, Ohio
1985-92	Assistant Professor, Department of Computer Science, Kent State University, Kent, Ohio
1987-89	Member of Technical Staff, Network Systems and Computer Architecture Group (on leave from Kent State University) (Worked as sole PI on the projects related to Switching Networks, Adaptive Routing in ISDN networks, digital circuit terminal adapter protocols)

Selected Research Publications

1. Reem Alshahrani and Hassan Peyravi. Cloud computing centers modeling and performance analysis. In GLOBECOM, pages 1–7. IEEE, 2019.
2. Reem Alshahrani and Hassan Peyravi. Cluster load estimation for stateless schedulers in datacenters. In 17th International Symposium on Network Computing and Applications (NCA)NCA, pages 1–4. IEEE, 2018.
3. Reem Alshahrani and Hassan Peyravi. Adaptive probe size estimation for cluster management in datacenters. In GLOBECOM, pages 1–7. IEEE, 2018.
4. Hassan Peyravi and Rahul Sehgal. Link modeling and delay analysis in networks with disruptive links. ACM Trans. Sen. Netw., 13(4):31:1–31:25, September 2017.
5. Reem Alshahrani and Hassan Peyravi. Resources management and performance analysis in datacenter networks. In 2017 International Conference on Computational Science and Computational Intelligence (CSCI), pages 1–7. ACM, 2017.
6. Rahul Sehgal and Hassan Peyravi. End to end delay analysis in delay tolerant networks. International Journal of Computers and Their Applications, 22(3):102–109, September 2015.
7. Rahul Sehgal and Hassan Peyravi. Delay tolerant networks modeling and analysis. In 30th International Conference on Computers and Their Applications, March 2015. Best Paper Finalist.
8. J. Hoblos and H. Peyravi. End-to-end throughput capacity in multi-hop wireless networks. International Journal of Wireless and Mobile Computing, 8(3):213–220, 2015.

9. Reem Alshahrani and Hassan Peyravi. Modeling and simulation of data center networks. In Proceedings of the ACM SIGSIM Conference on Principles of Advanced Discrete Simulation, SIGSIM-PADS '14, pages 75–82, New York, NY, USA, May 2014. ACM.
10. Yasir Drabu and Hassan Peyravi. Planning with joint clustering in multi-hop wireless mesh and sensor networks. In Proceedings of the 10th International Conference on Networks, St. Maarten, The Netherlands, January 2011.
11. J. Hoblos and H. Peyravi. Access disparity mitigation in multi-hop wireless networks. International Journal of Wireless Information Networks, 22(2):85–96, 2015.
12. Jalaa Hoblos and Hassan Peyravi. Fair access rate (FAR) provisioning in multi-hop multi-channel wireless mesh networks. In Proceedings of the International Congress on Ultra-Modern Telecommunications and Control Systems (ICUMT), pages 68–73, Moscow, Russia, October 2010.
13. Md Amiruzzaman, Hassan Peyravi, Mohammad Abdullah-Al-Wadud, and Yoojin Chung. Concurrent covert communication channels. In Proceedings of the Advances in Computer Science and Information Technology, pages 203–213, Miyazaki, Japan, June 2010.

Selected Extramural Funding

1. NASA Space Communications Division. Multiple access control (MAC) protocols for the mars regional network. NASA, 1994. PI, $19,200.
2. NASA Space Communications Division. Performance evaluation of the multiple access control (MAC) protocols for the mars regional network. NASA, 1995. PI, $90,000.
3. CAIDA (Cooperative Association for Internet Data Analysis). Internet engineering laboratory. Equipment grant, 2000. PI, $300,000.
4. Internet2 Technology Evaluation Center. Traffic management and QoS provisioning in IP networks. 2001. PI, $149,900.
5. Allied Telesyn. Internet engineering laboratory(equipment). 2002. PI, $7,000.
6. State Department. Fulbright, council for international exchange scholars. 2012. Participant, $99,613.
7. Cisco Systems. Network equipment: An infrastructure grant. 2012. PI, $220,000.
8. State Department. Fulbright, council for international exchange scholars. April 2013. Participant, $100,000.

Graduate Supervision (30+)

- **Theses & Dissertation:** Directed four PhD Dissertations and 26 MS theses; graduate Committees (over 100).

Relevant Graduate Courses Taught

- Relevant Courses Taught: Computer Communication Networks (senior/graduate). Advanced Communication Networks (graduate), Distributed Processing and Interconnection Networks (graduate), Wireless and Mobile Computing (graduate), Network Security (graduate), Master/Doctoral Seminars

Synergistic Activities

- NSF Panel Reviews (2007-present): Engineering Division: 2007, 2008(2), 2009(2), 2011, 2012(2), 2013(3), 2013(3), 2014(2), 2015(1).
- Publications Reviews (2010-present): IEEE Transactions on Computers, IEEE Transactions on Parallel and Distributed Systems, IEEE Communications Letters, IEEE Communications Magazine, Journal of Parallel and Distributed Computing, Parallel Processing Letters, Computer Communications, Journal of Supercomputing, IEEE Communications, IEEE Networks, IEEE Transactions on Vehicular Technology. IEEE Transactions on Wireless Communications. Computer Communications Journals, IEEE INFOCOM.
- Multiple years of computer science program development as curriculum and graduate program coordinator

Augustine S. Samba, PhD

Full Professor (Computer Science) non-tenure track

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Education

1977 BSc (Honors), Pure and Applied Math, Fourah-Bay College, UK

1979 MSc, Applied Math, The University of Liverpool, UK

1983 Ph. D., Computer Science, The University of Liverpool, Liverpool, UK

Experience

2019 -	Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2016 — 19	Assoc. Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2008 — 16	Assoc. Professor, College of Aeronautics and Engineering, Kent State University, Kent, Ohio, USA
2007 — 08	Assoc. Professor, Department of Computer Science, Kent State University, Kent, Ohio
2004 — 07	Visiting Asst. Professor, Department of Computer Science, Kent State University, Kent, Ohio, USA
2000 — 04	Director, Network Architecture, QuikCAT Technologies, Cleveland, Ohio, USA
1986 — 2000	Systems/Software Engineer, Telecom Network Systems Division, AT&T Bell Labs, NJ, USA

Fellowships

2013 Fullbright scholar

2012 Fulbright scholar

Selected Publications and Patents

1. Augustine S. Samba, US 8,868,725 B2 "Apparatus and Methods for Real-time Multimedia Network Traffic Management and Control in Wireless Networks," October 2014.
2. Augustine Samba, "Logical Data Models for Cloud Computing Architectures", *IEEE IT Professional Journal on Cloud Computing*, Manuscript ITProSI-2011- 06-0048.R2, pp. 19 – 26., Feb. 2012.
3. Augustine Samba, and Irena Bojanova, "Analysis of Cloud Computing Architecture Models"; Advanced Information Networking and Applications (WAINA)," *IEEE Workshops of International Conference*, ISBN: 978-0-7695-4338-3, 2011.
4. Augustine Samba, "Intelligent Traffic Management and Control in Telecommunications Network," In the *Proceedings of Spring Simulation Multi-conference,* Sponsored by Society for Modeling and Simulation International, April 2005, ISBN: 1-56555-296-2, pp. 97-104.
5. Augustine Samba, Atila Boros, Olu E. Lafe, US 2002/0196793 A1, End-User Communication Systems Access Network, December 2002.
6. Augustine Sylvester Samba, Anthony Buttitta, US 6,289,095 B1: NPA Split Management in Intelligent Network Environment, September 2001.
7. Augustine S. Samba, US 5,539,815A: Network Call Routing Controlled by a Management Node, July 1996.

Relevant Courses Taught

1) Advanced Digital Design (graduate level); 2) Capstone Project (undergraduate level); 3) Drone Programming

Synergistic Activities

- 12/31/2010: FAA research proposal 00000670: Inter-Operable benefits Analysis Management (IBAM) System; I. Richmond Nettey, (PI), & Augustine Samba, (Co-PI); ($478, 825).
- 8/3/2009: NSF research proposal 0959757. MRI-R2: Development of a Flying Cyber Laboratory: A Multi-Use Cyber Sharable Test Bed for Experiments in Motion Networking, Aviation Computing & Systems, and Aerial Remote Sensing; Javed Khan (PI), Joseph D Ortiz (CO-PI), Timothy Palcho (CO-PI), Hassan Peyravi (CO-PI), Augustine Samba (CO-PI). ($3, 439, 076)

Graduate MS Student Research Projects Directed

2015	Jayakrishnan Ajayakumar, "Using Geonarratives to understand Resident Environmental Perception and their Implications."
2014	Devagiri Sai Sowmya Chalamala, "Network assisted mobile computing with optimal uplink query processing."
2014	Santhoshini Vallakati, "Error Correcting Codes for Wireless Communications."
2014	Uday Bhaskar Madduru Prasad, "Artificial Intelligence Browser Using Java Speech API."
2014	Jaswanth Kumar Kanamarlapudi, "Highway's Electronic Toll Collection System,"
2014	Kay Levandowski, M.Ed., Career Readiness Tracking: Using Systems to Drive Participation in [KSU] Career Services."
2014	Prasanna Joshi, "Technical Architecture with CRM Implementation and Cloud Platform."
2013	Pavan Kumar Kodali, "Next Generation Intelligent Network."
2013	Shanthan Kumar Jogavajjala, "Network Management for Power Line Communication."
2013	Sandra Renea Randulic, " Customer Relationship Management System: The right system for the College of the Arts at Kent State University."
2013	Sirisha Yalamanchili, "Security in Fiber Optics Networks."
2013	Vijay Karthik Battina, "Microcontroller Based Security Authentication for Car using GPS."
2013	Nuttapong Phantkankum, "Multiprotocol Label Switching."
2012	Tahani Aljohani, "Network Traffic Management Techniques."
2012	Terence F. Tama, "WiMAX 802.16e: 4G wireless Broadband High-Speed network."

Gokarna Sharma, PhD

Assistant Professor (Computer Science)

Director —Scalable Computer Architecture and Emerging Technologies Laboratory

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Education

2005	B. E. (Computer Engineering), Tribhuvan University, Kirtipur, Nepal,
2007	M. S. (Computer Science), Technical University of Vienna, Vienna, Austria **and**
2008	M. S. (Computer Science), Free University of Bolzano, Bozen-Bolzano, Italy
2014	Ph. D. (Computer Science), Louisiana State University, Baton Rouge, USA
2014-15	Post-doc, Distributed Computing, Louisiana State University, Baton Rouge, USA

Experience

Aug. 2015 – current	Assistant Professor, Kent State University, Kent, Ohio, USA
Nov. 2014 – Aug. 2015	Postdoctoral Researcher, Louisiana State University, Baton Rouge, USA

Research Grants

G. Sharma (sole PI). NSF CCF-1936450 EAGER: Transactional Memory Foundations for Distributed Multiprocessor Systems, 10/2019-09/2021, $199,977.

Selected Publications

1. R. Jayaram, G. Sharma, S. Tirthapura, and D.P. Woodruff. Weighted Reservoir Sampling from Distributed Streams. In Proceedings of the 38th ACM SIGMOD-SIGACT-SIGAI Symposium on Principles of Database Systems **(PODS** 2019), Amsterdam, Netherlands, July 2019.
2. C. Busch, M. Herlihy, M. Popovic, G. Sharma. Time-Communication Impossibility Results for Distributed Transactional Memory. In *Distributed Computing* **31**(6): 471-487, November 2018.
3. S. Rai, G. Sharma**,** C. Busch, M. Herlihy. Load Balanced Distributed Directories. In Proceedings of the 20th International Symposium on Stabilization, Safety, and Security of Distributed Systems (**SSS** 2018), Tokyo, Japan, November 2018.
4. P. Poudel, G. Sharma. An Adaptive Logging Framework for Persistent Memories. In Proceedings of the 20th International Symposium on Stabilization, Safety, and Security of Distributed Systems (**SSS** 2018), Tokyo, Japan, November 2018.
5. C. Busch, M. Herlihy, M. Popovic, G. Sharma. Fast Scheduling in Distributed Transactional Memory. In Proceedings of the 29th Annual ACM Symposium on Parallelism in Algorithms and Architectures (**SPAA** 2017), Washington, D.C., USA, July 2017.
6. G. Sharma, C. Busch. A Load Balanced Directory for Distributed Shared Memory Objects. *Journal of Parallel and Distributed Computing* **78**: 6-24, April 2015.
7. G. Sharma, C. Busch. An Analysis Framework for Distributed Hierarchical Directories. *Algorithmica,* **71**(2): 377-408, February 2015.
8. G. Sharma, C. Busch. Distributed Transactional Memory for General Networks. In *Distributed Computing* **27**(5): 329-362, October 2014.

9. G. Sharma, and C. Busch, "Window-Based Greedy Contention Management for Transactional Memory: Theory and Practice," In *Distributed Computing,* **25**(3): 225-248, June 2012.

10. G. Sharma, and C. Busch, "A Competitive Analysis for Balanced Transactional Memory Workloads," *Algorithmica,* **63**(1-2): 296-322, June 2012.

Research Directed

- Rusul Alsaedi. M.S., On the mutual visibility of fat mobile robots, May 2016.
- Aisha Aljohani. M.S., Distributed robot coordination handling obstructions and faults, December 2017
- Pavan Poudel. Ph.D. Tools and techniques for efficient transactions, Expected graduation: August 2020

Research Significance

The research on transactional memory the group has established solid theoretical understanding of power and limitations of transactional memory in programming tightly-coupled shared memory and loosely- coupled distributed multiprocessor systems. The techniques developed found applications in different areas such as mobility handling in sensor networks.

Relevant Graduate Courses Taught

1) Internet of Things; 2) Algorithmic Robotics.

Synergistic Activities

- Research advisor of several undergraduate students under Choose Ohio First (COF) program of Kent State University.
- Organizing committee member as a workshops chair for the 32nd International Symposium on Distributed Computing (**DISC** 2018).
- Judge, mentor, and selection board member for several high school and undergraduate research events, most recently including the KSU science experience internship program for the high school students in the city of Kent, Ohio.
- External reviewer for meetings of several different professional societies, most recently including the 29thACM-SIAM Symposium on Discrete Algorithms (**SODA** 2018).
- Editorial board member and reviewer for journals of several professional societies, most recently including Journal of Parallel and Distributed Computing and Transactions on Robotics.

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Education

2006 Ph. D., Computer Science, Stony Brook University, New York, USA
2000 M. S., Computer Science, Tsinghua University, Beijing, China
1997 B. S., Computer Science, Tsinghua University, Beijing, China

Experience

2017 – Present	Graduate Coordinator, Department of Computer Science, Kent State University, Ohio
2017 to Present	Full Professor, Department of Computer Science, Kent State University, Ohio
2012 — 2017	Associate Professor, Department of Computer Science, Kent State University, Ohio
2006 — 2012	Assistant Professor, Department of Computer Science, Kent State University, Ohio

Selected Publications

1. Gennady Andrienko, Natalia Andrienko, Wei Chen, Ross Maciejewski, Ye Zhao, Visual Analytics for Transportation: State of the Art and Further Research Directions, *IEEE Transactions on Intelligent Transportation Systems*, 18(8), 2232 - 2249, Aug.,2017, IEEE.
2. Shamal AL-Dohuki, Farah Kamw, Ye Zhao, Xinyue Ye, Jing Yang, An Open Source TrajAnalytics Software for Modeling, Transformation and Visualization of Urban Trajectory Data, *the 22nd IEEE Intelligent Transportation Systems Conference*, to appear, Auckland, New Zealand, October 2019 IEEE.
3. Farah Kamw, Shamal AL-Dohuki, Ye Zhao, Thomas Eynon, David Sheets, Jing Yang, Xinyue Ye, Wei Chen, Adaptively Exploring Population Mobility Patterns in Flow Visualization, *IEEE Transactions on Intelligent Transportation Systems*, 2019,
4. Shamal AL-Dohuki, Ye Zhao, Farah Kamw, Jing Yang, Xinyue Ye, Wei Chen, QuteVis: Visually Studying Transportation Patterns Using Multi-Sketch Query of Joint Traffic Situations. *IEEE Computer Graphics and Applications*, 2019,
5. Xiaoke Huang, Ye Zhao, Jing Yang, Chao Ma, Chong Zhang, Xinyue Ye, TrajGraph: A Graph-Based Visual Analytics Approach to Studying Urban Network Centrality Using Taxi Trajectory Data, *IEEE Transactions on Visualization and Computer Graphics*, 22(1), 160-169, 2015.
6. Zhaosong Huang, Ye Zhao, Wei Chen, Shengjie Gao , Kejie Yu, Weixia Xu, Mingjie Tang, Minfeng Zhu, Mingliang Xu, A Natural-language-based Visual Query Approach of Uncertain Human Trajectories. *IEEE Transactions on Visualization and Computer Graphics*, 2019.
7. Fully Parallelized Lattice Boltzmann Scheme for Fast Extraction of Biomedical Geometry, Zhiqiang Wang, Ye Zhao, Huidan Yu, Chen Lin, Alan P Sawchuck, *Journal of Parallel and Distributed Computing*, Volume 128, Pages 126-136, 10.1016/j.jpdc.2019.02.004, June 2019.
8. Fei Wang, Wei Chen, Ye Zhao, Tianyu Gu, Siyuan Gao, Hujun Bao, Adaptively Exploring Population Mobility Patterns in Flow Visualization, *IEEE Transactions on Intelligent Transportation Systems*, 18(8), 2250 - 2259, Aug. 2017.

9. Shamal AL-Dohuki, Farah Kamw, Ye Zhao, Jing Yang, Chao Ma, YingyuWu, Xinyue, Ye, Fei Wang, Wei Chen, Xin Li, SemanticTraj: A New Approach to Interacting with Massive Taxi Trajectories***,*** *IEEE Transactions on Visualization and Computer Graphics*, 23(1), 11 - 20, 2017.

Software

1. ***TrajAnalytics***: A Web-Based, Open Source Visual Analytics Software of Urban Trajectory Data. Free download at vis.cs.kent.edu. Supported by NSF grant 1535031.
2. ***GeoVisuals***: A Web-Based, Open Source Visual Analytics Software Supporting Data Management and Visualization of Geospatial Multimedia Data. Free download at vis.cs.kent.edu. Supported by NSF grant 1739491.

Research Directed

Directed seven PhDs and nine MS to completion in analytics of smart city and intelligent transportation, information visualization, analysis and retrieval of urban information, biomdical geometry extraction, and scientific visualization of turbulent fluid motion. Currently, his lab has six PhD students.

Extramural Grants (More than $1.5 million in grants)

1. Brookhaven Science Associates, DOE, Subaward PI, Using Visualization for Explainable Machine Learning
2. Brookhaven Science Associates, DOE, Subaward PI, Full Stack Development for Scientific Data Analysis and Visualization
3. National Science Foundation Grant OAC-1739491, PI, GeoVisuals Software: Capturing, Managing, and Utilizing GeoSpatial Multimedia Data for Collaborative Field Research
4. National Science Foundation Grant CNS-1637242, PI, S&CC: Support Community-Scale Study by Visual Analytics of Human Mobility and Opinion Data from Social Media Data
5. National Science Foundation Grant ACI-1535031, PI, TrajAnalytics: A Cloud-Based Visual Analytics Software System to Advance Transportation Studies Using Emerging Urban Trajectory Data
6. National Science Foundation Grant IIS-1352927, PI, Visualizing event dynamics with narrative animation
7. National Science Foundation Grant IIS-0916131, PI, Real-time simulation system of turbulent fluids.

Related Graduate Courses Taught

1) Information Visualization; 2) Scientific Visualization; 3) Advanced Computer Graphics

Synergistic Activities

- Principle Investigator of extramural funding with a total amount more than 1.5 million dollars from 2009 - current, including NSF 1739491
- Recipient of the Google Faculty Research Awards, 2011
- Program Committee member for many conferences including IEEE Conference on Visual Analytics Science and Technology (VAST)
- Grant Reviewer for several panels of National Science Foundation 2009-2018
- Paper Reviewer for many top journals and conferences including IEEE Trans. On IEEE Transactions on Visualization and Computer Graphics