KENT STATE UNIVERSITY
CERTIFICATION OF CURRICULUM PROPOSAL

Preparation Date **20-Dec-18** Curriculum Bulletin _____
Effective Date Fall 2020 Approved by EPC _____

Department **CS**
College **AS - Arts and Sciences**
Degree **MS - Master of Science**
Program Name **Artificial Intelligence** Program Banner Code
Concentration(s) Concentration(s) Banner Code(s)
Proposal **Establish program**

Description of proposal:
This is the required Program Development Plan to establish a new major within the Masters of Science Degree in Artificial Intelligence hosted by the Department of Computer Science.

Does proposed revision change program's total credit hours? ☐ Yes ☒ No
Current total credit hours: Proposed total credit hours **30**

Describe impact on other programs, policies or procedures (e.g., duplication issues; enrollment and staffing considerations; need; audience; prerequisites; teacher education licensure):
This is a new degree in the recently invigorated field of Artificial Intelligence. While primarily a subfield of computer science, it draws on knowledge from other disciplines, principally biology and psychology, and is expected to have applications to most aspects of education and technology.

Units consulted (other departments, programs or campuses affected by this proposal):
A&S cooperating departments/Institutes: Biological Sciences (BSCI); Psychology

REQUIRED ENDORSEMENTS

_____ 3/1/2019
Department Chair / School Director

_____ ___/___/___
Campus Dean (for Regional Campuses proposals)

_____ ___/___/___
College Dean (or designee)

_____ ___/___/___
Dean of Graduate Studies (for graduate proposals)

_____ ___/___/___
Senior Vice President for Academic Affairs and Provost (or designee)

KENT STATE UNIVERSITY

DEPARTMENT OF COMPUTER SCIENCE

Program Development Proposal

MASTERS OF SCIENCE DEGREE in

ARTIFICIAL INTELLIGENCE within

Department of Computer Science

STARTING FALL 2020

Contents

1. Designation, Rationale and Significance

The program will be designated as "**Masters of Science in Artificial Intelligence**." It will be hosted within the Department of Computer Science at Kent State University. The program will prepare students for research and development in artificial intelligence and its industrial applications.

Artificial intelligence is the simulation of the human intelligence, vision, behavior, interaction and learning using computational techniques with a goal to design and create intelligent systems. Simulation of human intelligence includes heuristic search, inferencing and cognition, machine learning (such as neural networks etc.), probabilistic reasoning, game and strategy, prediction, planning, pattern analysis, resource optimization, image processing, object and scene recognition, knowledge acquisition and representation, intelligent automation, resource optimization, natural language processing and understanding, and robotics.

Artificial Intelligence (AI) is the current digital frontier for the next twenty years and beyond. With the major societal drive in automation to improve productivity and resource utilization, the need for artificial intelligence has been growing at an annual rate of 30-40% in the USA[1] (Source: Accenture report – see the footnote for the link).

Industry giants such as Amazon, Facebook, Google, IBM and Microsoft, etc., are spending billions of dollars in development of industrial applications. Various companies have invested around 25-40 billion dollars[1] (Accenture report – see the footnote) in AI-related infrastructure such as robotics, automotive and assembly, intelligent pattern analysis, speech recognition systems, face recognition systems, health care analytics, media/entertainment, financial services, education, travel/tourism, smart homes and cities, intelligent transportation, and intelligent cybersecurity. According to a study by Accenture, the AI-based optimizations will give an estimated boost of fourteen trillion dollars with a 38% industrial growth by the year 2035[1]. It is anticipated that the economic growth will double by 2035[1] due to the AI- applications.

To meet such a high-sustained demand for AI, the educational system has to produce graduates with AI knowledge and related areas at a faster rate. Due to the limited supply of graduates, the gaps between the early AI adopters and the AI developers, who could speed up the process of adoption, is increasing. This gap is choking up the silent AI revolution in the retail, manufacturing, electric utility, health care, and education sectors. The problem will become grave when 41% of slow adapters and 40% of contemplators also join the revolution[2, 3]. It is estimated that there are 10,000 jobs to be filled representing around $650 million in salary[2] (see the footnote for the link).

In January 2018, the US Congress enacted the Bill H.R. 4829[4] to identify and promote industries that can benefit from Artificial Intelligence applications, improve the AI labor force, and enhance AI literacy to improve human life in various fields. Significant US research and industry funding is expected.

While four to five top universities such as Carnegie Mellon University have pioneered AI degree programs for the last two decades, in the last 5−7 years, international and national universities have created MS programs in Artificial Intelligence (see Appendix III) owing to its increasing application to industry and society. Although KSU does not have the named degree program, the Department of Computer Science has been offering undergraduate and graduate-level courses in Artificial Intelligence (AI) since 1988. The department has been graduating students with Masters in AI-related areas since 1985 and PhDs since the year 2001. Kent State University has the faculty and active researchers, courses and labs in artificial intelligence and AI-related fields.

In the last five years, the Department of Computer Science, keeping up with the national growth, has expanded the AI-related curriculum and faculty strength to include automation and robotics, smart devices, intelligent analytics and smart communities, and AI in healthcare and education. Their impact on the society and industry will be enhanced by structuring and focusing on the AI-related curriculum in the proposed degree program.

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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]McKinsey report link: www.mcKinsey.com/mgi

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

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

To our knowledge, among our peer group of Universities in the *State of Ohio*, the University of Cincinnati has created a MS program in Artificial Intelligence (Appendix IV, Table 5) with a restricted choice of curriculum in AI-related courses. All other programs in the state support AI research with MS/PhD degrees in Computer Science. The proposed program will enhance the competence level required for a new wave of the emerging, knowledge-based industry of the 21st century. The program will also supply the much-needed workforce for important Ohio industries, including automobile, block-chain, robotics, energy-sector, health-care, etc.

2. Proposed Curriculum

The proposed program will award the *Master of Science degree in Artificial Intelligence* to students following the successful completion of a proposed two-year curriculum. The program model has been carefully calibrated with respect to the MS programs in AI offered by leading universities in the United States, Europe, and Japan (see Appendix III) and builds on the existing faculty and course strength within the Department of Computer Science at Kent State University.

2.1 *Program Structure*

The entry requirement for this program will be a bachelor's degree in computer science, computer engineering or closely related area with undergraduate level courses in 1) algorithms; 2) operating systems (recommended); 3) databases; 4) data structures; and 5) probability and statistics, and 6) programming skills.

The program will have two pathways: 1) *MS thesis option* for students involved in industrial research or who are planning to continue into PhD study; and 2) *MS non-thesis option* for those aspiring to join industry. Both tracks will require 30 credit hours. There are 12 credits of core courses (four lecture courses). There are 12 hours of elective courses (four lecture courses) for the thesis option and 12 credits of elective-courses (four courses) for the non-thesis option. The culminating experiences are the thesis (six credit-hours) for the thesis pathway; industrial project (3 or 6 credit-hours) and an optional industrial internship (3 credit-hours) for the non-thesis pathway. In the non-thesis pathway, students choosing an internship will have a shorter 3 credit-hours industrial project. A student can take an advisor-approved thesis/project related to elective courses from a project-related discipline such as cognitive psychology and biological sciences for intelligent omics (genomics, proteomics, transcriptomics).

2.2 Departmental Preparedness

The Department of Computer Science is teaching 23 AI-related graduate courses by tenured and tenure-track graduate-status faculty members. The Department has graduated over 40 MS students with a thesis and fourteen PhD students exclusively in artificial intelligence. Out of twenty research faculty, nine faculty members are active in AI research, and have graduated MS and/or PhD students in AI.

2.3 Course Structure

Four core courses are being taught annually. Out of the 19 elective courses, 18 are established courses, and are taught regularly in a rotation schedule. For the culminating experience, the internship (3 credit hours) and Capstone project (3 or 6 credit hours) are under development for the non-thesis pathway. The thesis (6 credit hours) for the thesis pathway is already established. The details of the courses are given in Table I. The list of graduate faculty with active research teaching the courses is given in Appendix VIII.

The electives reflect three focus-areas: 1) robotics(**R**); 2) intelligent analytics (**IA**); and 3) smart communities and automation (**SA**). A graduate faculty (with PhD degree) will guide the students in the selection of the courses to reflect specialization in the three areas. At least, seven recommended electives in each focus area are being offered in a rotation schedule. The focus areas are mentioned after the course name within a parenthesis.

Table I: Course Structure and List of Courses

Core Courses (12 credit hours – four lecture courses)	
CS 54201 Artificial Intelligence (3 cr)	CS 64201 Adv. Artificial Intelligence (3 cr.)
CS 54202 Machine and Deep Learning (3 cr.)	CS 63005 Adv. Database Syst. Design (3 cr.)
Electives (12 credit hours – four lecture courses)	
CS 53301 Software Dev. For Robotics **(R)**	CS 53302 Algorithmic Robotics **(R)**
CS 53303 Internet of Things **(SA)**	CS 53305 Advanced Digital Design **(R)**
CS 53334 Human-Robot Interaction **(R)**	CS 57201 Human Computer Interaction **(SA)**
CS 63015 Data Mining Techniques **(IA)**	CS 63016 Big Data Analytics **(IA)**
CS 63017 Big Data Management **(IA)**	CS 63018 Probabilistic Data Management **(IA + SA)**
CS 63100 Computational Health Informatics **(SA)**	CS 63306 Embedded Computing **(SA)**
CS 64301 Pattern Matching Principles **(R + SA + IA**)	CS 64401 Image Proc. and Comput. Vision (**R + SA**)
CS 64402 Multimedia Syst. and Biometrics **(IA+ SA)**	CS 65203 Wireless and Mobile Comm. **(R + SA)**
CS 67301 Scientific Visualization **(IA)**	CS 67302 Information Visualization (**IA + SA**)
ZZ XXXXX Interdisciplinary elective from thesis/project related discipline as approved by the advisor	
Culminating experience (six credit thesis OR 3 credit non-thesis project)	
Non-thesis Option	**Thesis Option**
CS 69092 Internship (0 – 3 cr.) (under dev.)	CS 69199 Thesis I (6 cr.)
CS 69099 Capstone project (3 - 6 cr.) (under dev.)	

3. Culminative Experience

The MS-thesis option will have a six credit hour research thesis evaluated by a committee of three faculty members with graduate faculty status. The thesis will contain both theoretical contributions and software development. The MS non-thesis option will have 3 or 6 credit hours of project development and up to 3 credit hours of optional practical training. Project development will involve problem-solving and the software development of a substantial industrial project. The projects and thesis will have input from the industrial board based upon their needs and their projection of future market needs.

4 Administrative Arrangement

The program will be administered by the department in a similar way other graduate programs are run by the departmental Graduate Studies Committee (GSC). In the initial years, the GSC will have a subcommittee that will look after the policy developments, admissions screenings, advising, establishing industrial relationships, promotion and documentation creation, and for ensuring sound operation and growth of the program. After the program stabilizes, the GSC will manage the program similar to other existing programs in the Department of Computer Science. The graduate program policies are recommended by a graduate committee headed by a graduate coordinator. All members of the graduate committee are active researchers with PhD granting graduate faculty status. Graduate coordinator recommends the policies to the associate graduate dean.

5 Evidence of Need for the New Program

There is ample evidence to justify the need for more AI based degrees. Confirmation of the growth in AI is found in the surge of investments in AI by venture capitalists, the upswing of startup AI companies (see Appendix II), the enaction of the Congressional bill HR 4289[4], evidence of the increase of AI jobs in recent years after 2010 (see Appendix I), the US Congress mandate of automated computational health

informatics, and the interest in the increasing use of robotics in various fields. According to New York Times[5], salaries of an AI graduates can be high. The commercial job website[6] reports various types of jobs for an MS in Artificial Intelligence. Some statistics from Forbes investment magazine showing steep demand and investment in AI startups are shown in Appendix II. According to a market survey company[7], the intelligent personal robot market itself will be $12.36 billion in size by 2023. The Bureau of Labor statistics groups Artificial Intelligence under the class "Computer and Information Research Scientist" with median income of $114,520 and employment growth of 19% and much faster than other computer occupations (employment growth rate 13%) and all other occupations (employment growth 7%) for the decade 2016-2026.

A survey done from the employers at the national level by Accenture shows that around 50% of the corporate executives are convinced that AI employed by them is highly successful[9]. A direct survey of twenty BS students taking undergraduate AI course showed that 50% students will take/consider Masters in AI when offered (see Appendix V). A broader direct survey of 221 computer science majors (junior and senior BS-level students) was also conducted. 98% (214 out of 221) students supported MS in AI, and 86% (186 out of 221) students were interested in doing graduate-level courses in AI (see Appendix VI).

6 Prospective Enrollment

The program will be advertised nationally, internationally (through KSU Office of Global Education and department's global partnerships), and regionally through various direct outreach programs (such as the department's *CSforAll* workshop series for North East 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, with the expectation to stabilize at 30-40 MS students in the next four years (May 2024) after the program starts. We anticipate a capacity reevaluation after the 4th year.

7 Effort to Enroll and Retain Minority Students

Minority students are traditionally underrepresented in computer science, including African-Americans, Native Americans, Latinos, and women. The MS program will be advertised to underrepresented undergraduate students groups within the university and other colleges at the national level. New proposals will be written to federal agencies and state agencies to attract funding for minority students under STEM initiatives. The university has many scholarships to encourage minority students, including women to STEM areas. The department has a student chapter of the ACM (Association of Computing Machinery) that organizes many student activities. The department also supports and funds students to attend "Women in CS" conferences. The department has a healthy record of enrolling and retaining female students. Based upon the last five years of departmental records, 24-45% (average 29%) of enrolled MS students are females, and 30-45% (average 33%) of the MS graduates are females (see Appendix VII).

8 Adequacy of the Facilities

The department has the required faculty and lab facilities for the program. Table II shows the research labs that will absorb the thesis/ project research work. Robotics-related projects will be developed in the *Tele-Robotics Lab*. The smart homes and cities projects, and embedded computing projects will be developed in the *Digital-Science Lab* and in the *Networking* (*and Communications*) *Lab*.

[5]NY Times AI salary link: https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html
[6]Commercial job website link: https://www.indeed.com/q-Ms-in-Artificial-Intelligence-jobs.html
[7]Survey link: https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-robots-market-120550497.html
[8]Bureau of Labor statistics link: https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm#tab-2
[9]Employment: https://www.accenture.com/t20180919T202227Z__w__/us-en/_acnmedia/PDF-86/Accenture-AI-Momentum-Final.pdf

Computational health informatics projects, intelligent speech recognition, natural language processing, humanoids, and core AI projects will be developed in the *Artificial Intelligence Lab*. Perceptual engineering and cognitive engineering projects will be developed in *Perceptual Engineering and Media Net Lab*. Information visualization projects will be developed in the *Visualization Lab*. Intelligent analytics projects will be developed in the *Big Data and Science Lab*, and/or *Artificial Intelligence Lab* depending upon the projects. Internet of Things and sensor networks projects will be developed in the *Distributed Systems Lab*. All the laboratories are well equipped with specialized and general-purpose computers.

The department also has two general-purpose teaching labs, and two 'special equipment educational labs' which are used for teaching lab sections in many courses. Each educational lab has twenty four desktops with recent technologies and a projector for presentations. These labs are sufficient for course-projects in intelligent analytics and software development for smart healthcare. 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.

Since 2012, the Department of Computer Science has operated a Data and Computing Center with advanced storage, virtual machine, and computing resources. There are also three research engineers within the CS program to support the software and hardware needs of the program.

Table II. Existing AI Program Related Research Laboratories in the Department

	Lab	Director	AI Related Research Activities
1	Artificial Intelligence	Arvind Bansal	Social Robotics, human-humanoid interaction, intelligent computational health informatics, intelligent analytics, knowledge bases, multimedia
2	Computer Vision and Image Processing	Cheng Chang Lu	Biological image processing, medical image processing, computer vision
3	Visualization	Ye Zhao	Urban planning, scientific visualization
4	Perceptual Engineering 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	Distributed Systems	Gokarna Sharma	Internet of Things, sensor networks, and distributed robotics algorithms
9	Networking	Hassan Peyravi	Wireless and mobile networks

9 Need for Additional Facilities

There is no need for additional facilities. Four educational labs will have sufficient capacity to absorb forty additional students in AI. Most of the intelligent analytics courses are lecture-based. Two educational labs will be used for running the special software needed for the courses. The department has sufficient internal capacity to absorb the overhead of required software systems and the needed GPU-like processors.

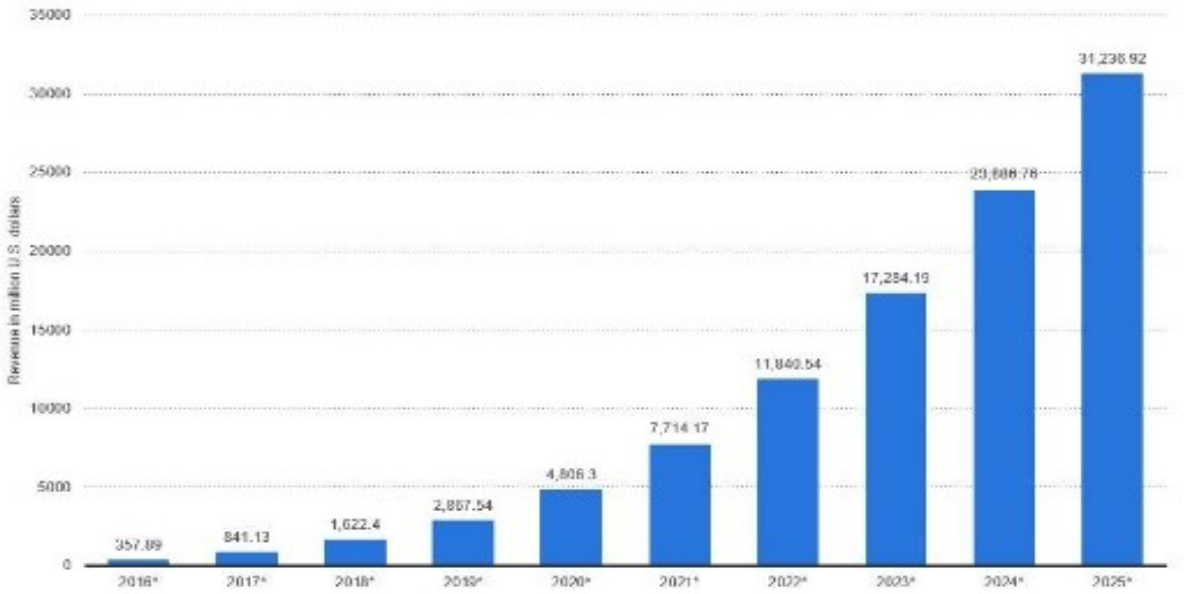
10 Projected Additional Cost and Institutional Commitment

There will be no additional cost with the regular projected growth.

APPENDIX I Employment Evidence of Graduates

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)



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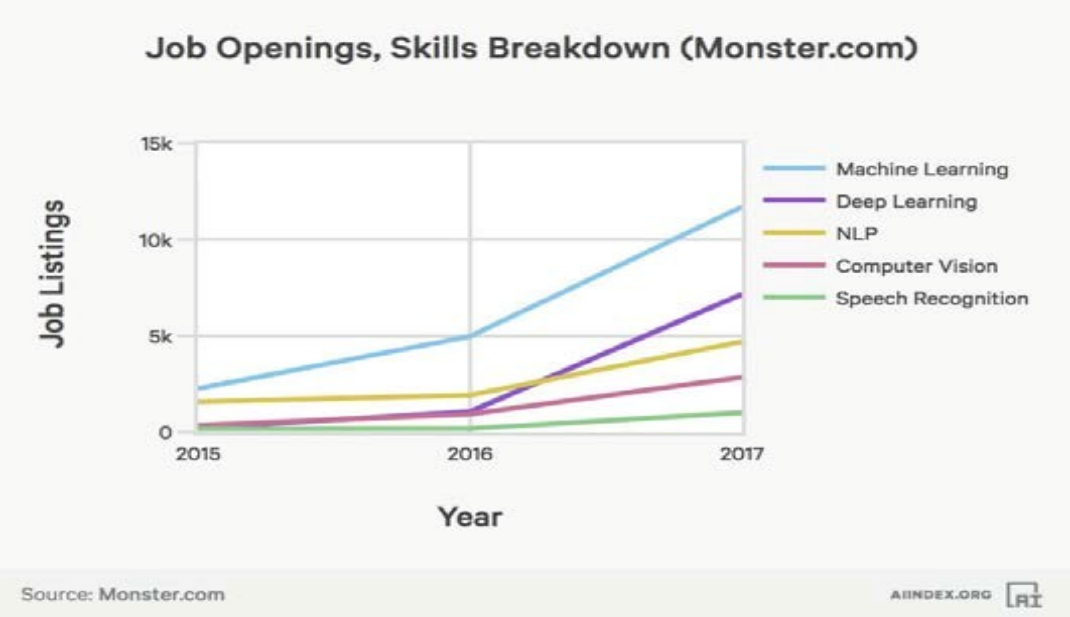
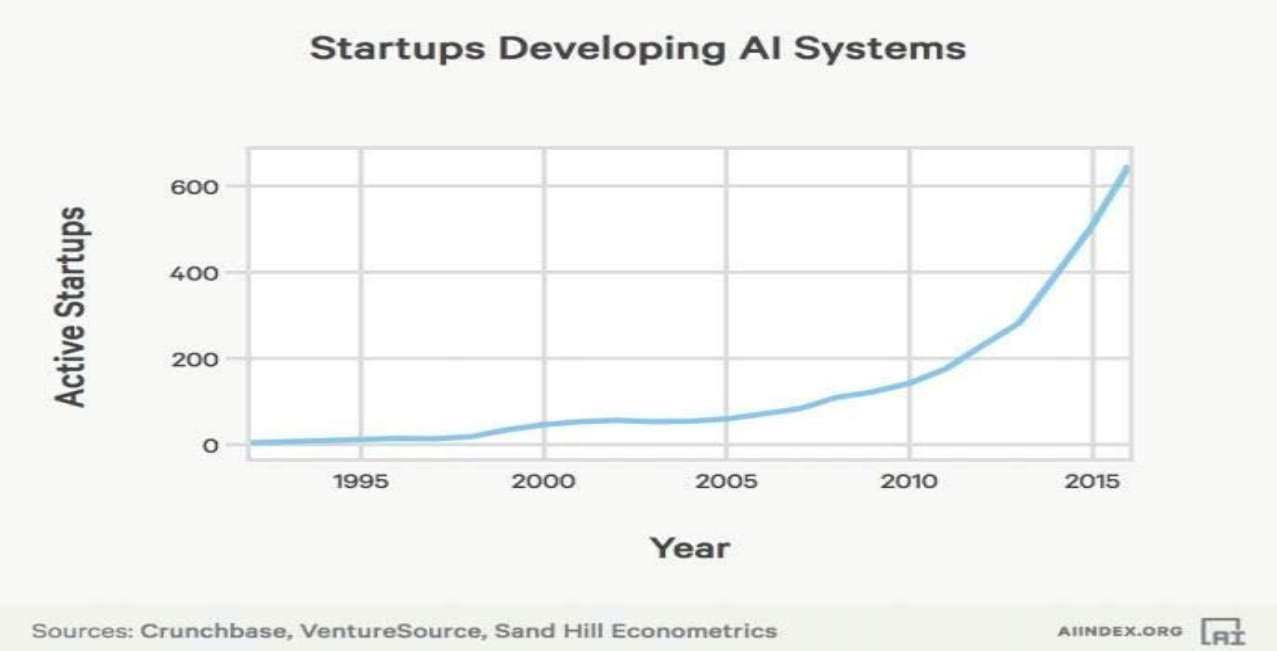
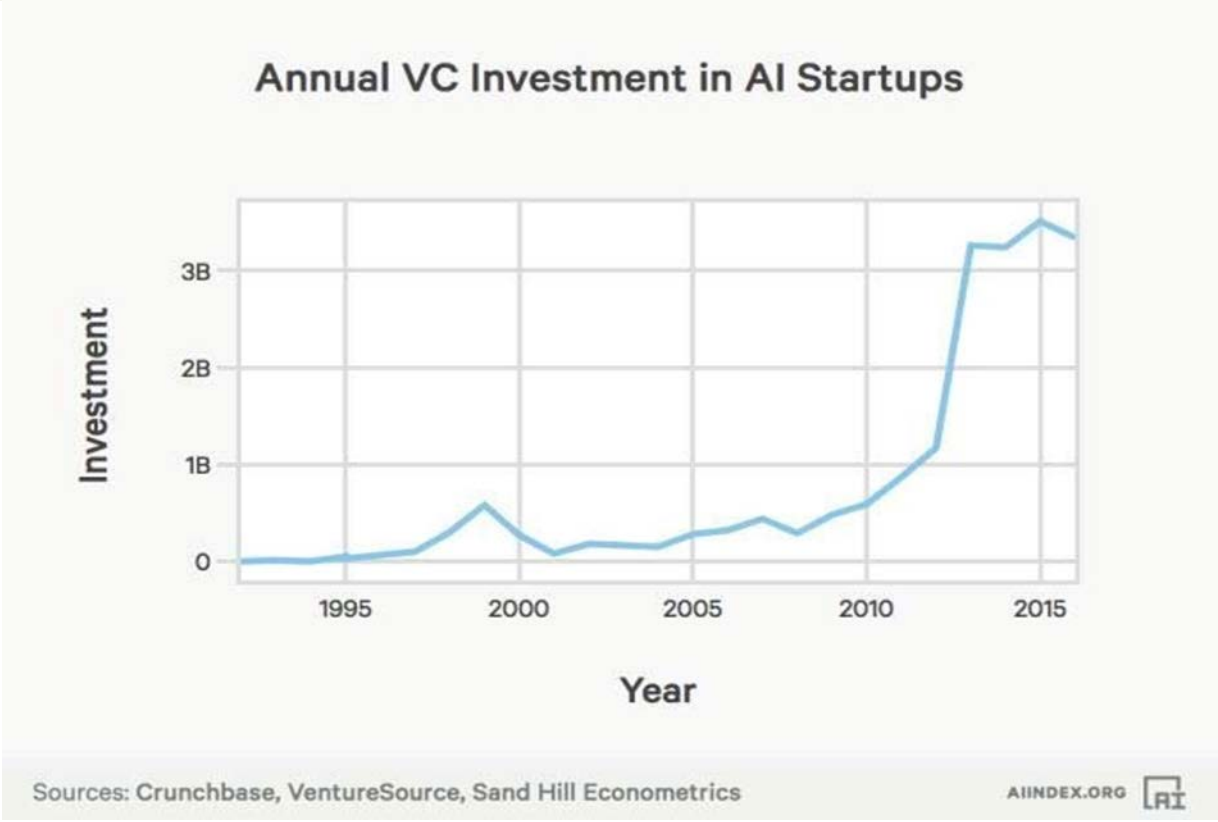


APPENDIX II Growth of AI Startups and Investments





Appendix III Partial List of Universities with Masters in Artificial Intelligence

Table 3. Partial List of US Universities with MS in Artificial Intelligence Related Program

	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.

Table 4. Partial List of International Universities with MS in AI-related Program

	International 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)	1. Artificial Intelligence

Appendix IV Status of Masters in AI Degree in Ohio and other Comparable Universities

Table 5 Status of MS in AI in Ohio Universities with PhD programs in Computer Science

	University	Status
1.	Ohio State University, Columbus, Ohio	No independent MS degree in AI. AI is research area of Computer Science.
2.	Case Western Reserve University, Cleveland, Ohio	No independent MS degree in AI. AI is research area of Computer Science. Minor in AI in BS program
3.	University of Cincinnati, Cincinnati, Ohio	Master of Engineering in Artificial Intelligence
4.	Wright State University, Dayton, Ohio	No independent MS degree in AI. AI is subarea of Computer Science.
5.	Ohio University, Athens, Ohio	No independent MS degree in AI. AI is subarea of Computer Engineering
6.	Cleveland State University	No independent MS degree in AI. AI is subarea of Computer Engineering

Table 6 Status of MS Degree in AI in Other Peer 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 V. 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 interest in pursuing Masters 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. *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***

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*

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 will 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*

Appendix VI. Survey of Junior and Senior CS Students

A detailed survey of junior and senior students in the Department of Computer Science was conducted. Three questions were asked as shown in Table 3. 221 students responded. The response was overwhelmingly positive. 86% students showed interest in taking AI course. 85% students showed interest in attending MS program in Artificial Intelligence. 98% students supported the creation of Master of Science degree in Artificial Intelligence within 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 a Master of Science degree in Artificial Intelligence?	216 (98%)	5 (2%)

Appendix VII. Enrollment and Graduation of Female Students in MS Computer Science

Enrollment Statistics in MS Computer Science for the Last Five Years

	Enrolled in MS Computer Science		
	Total Students	**Females**	**% of Females**
Spring 2019	51	12	24%
Fall 2018	64	20	31%
Spring 2018	58	17	29%
Fall 2017	70	26	37%
Spring 2017	110	38	35%
Fall 2016	156	57	37%
Spring 2016	184	68	37%
Fall 2015	192	65	34%
Spring 2015	177	54	31%
Fall 2014	161	47	29%

Graduation Statistics in MS Computer Science for the Last Five Years

	Graduated from MS Computer Science		
	Total Students	**Females**	**% of Females**
2018	49	22	45%
2017	107	37	35%
2016	108	34	31%
2015	82	18	22%
2014	53	16	30%

Appendix VIII. List of PhD Faculty Teaching the Listed Courses

	PhD Faculty Teaching Courses	List of Courses
1	Arvind Bansal	CS 54201; CS 63100; CS 64201; CS 63306; CS64402
2	Gokarna Sharma	CS 53302; CS53303;
3	Hassan Peyravi	CS 65203
4	Ye Zhao	CS 67301; CS 67302
5	Cheng Chang Lu	CS 64301; CS 64401
6	Xiang Lian	CS 63018; CS 63106
7	Kambiz Ghazinour Naini	CS 63015
8	Jong-Hun Kim	CS 53301; CS 53334;
9	Ruoming Jin	CS 53016; CS 54202;
10	JungYoon Kim / Augustus Samba	CS 53305
11	Kiang Guan	CS 63005

Core Courses (12 credit hours – four lecture courses)	
CS 54201 Artificial Intelligence (3 cr)	CS 64201 Adv. Artificial Intelligence (3 cr.)
CS 54202 Machine and Deep Learning (3 cr.)	CS 63005 Adv. Database Syst. Design (3 cr.)
Electives (12 credit hours – four lecture courses)	
CS 53301 Software Dev. For Robotics **(R)**	CS 53302 Algorithmic Robotics **(R)**
CS 53303 Internet of Things **(SA)**	CS 53305 Advanced Digital Design **(R)**
CS 53334 Human-Robot Interaction **(R)**	CS 57201 Human Computer Interaction **(SA)**
CS 63015 Data Mining Techniques **(IA)**	CS 63016 Big Data Analytics **(IA)**
CS 63017 Big Data Management **(IA)**	CS 63018 Probabilistic Data Management **(IA + SA)**
CS 63100 Computational Health Informatics **(SA)**	CS 63306 Embedded Computing **(SA)**
CS 64301 Pattern Recognition Principles (**R + IA + SA**)	CS 64401 Image Proc. and Comput. Vision **(R + SA)**
CS 64402 Multimedia Systems and Biometrics (**IA+ SA**)	CS 65203 Wireless and Mobile Comm. **(R + SA)**
CS 67301 Scientific Visualization **(IA)**	CS 67302 Information Visualization **(IA + SA)**
ZZ XXXXX Interdisciplinary elective from thesis/project related discipline as approved by the advisor	
Culminating experience (six credit thesis OR 3 credit non-thesis project)	
Non-thesis Option	**Thesis Option**
CS 69092 Internship (0 – 3 cr.) (under dev.)	CS 69199 Thesis I (6 cr.)
CS 69099 Capstone project (3 - 6 cr.) (under dev.)	

Appendix IX: Catalog Description of Courses

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 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 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 69199 THESIS I 2-6 Credit Hours
Thesis student must register for total of 6 hours, 2 to 6 hours in a single semester distributed over several semesters if desired.
Prerequisite: Graduate standing.
Schedule Type: Master's Thesis **Contact Hours:** 2-6 other **Grade Mode:** Satisfactory/Unsatisfactory-IP

Appendix X. Support Letter 1: 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

Appendix XI: Support Letter from a Major Multinational AI Industry in Ohio

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

Appendix XII: 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

Appendix XIII: Support Letter from Department of Biological Sciences, Kent State University

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

Appendix XIV : Support Letter from Department of Psychological Sciences, Kent State University

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