Letter of Intent to establish:

Master's Program in Artificial Intelligence in Medicine

Master of Science Degree

Contact: Martin G. O'Toole

Department of Bioengineering
J. B. Speed School of Engineering
University of Louisville

Department of Bioinformatics and Biostatistics
School of Public Health and Information Sciences
University of Louisville

Projected Program Begin Date: Spring 2024

Accreditation or Licensure Requirements:
None

Speed School Budget Approval:	Signature	Date
School of Public Health Budget Approval:	Signature	Date
Speed School Dean Approval:	Signature	Date
School of Public Health Dean Approval:	Signature	Date

This Letter of Intent and its related financial commitments have been approved by the Dean of the Speed of School of Engineering, Dr. Emmanuel Collins and the Dean of the School of Public Health, Dr. Craig Blakely.

I. Program Abstract (250 words or less). Describe the program's focus and purpose, primary area of study, intended audience, academic level (undergraduate, graduate or professional), length of the program, goals/objectives, the rationale for the program, the skills or knowledge that students will acquire, and the relationship of the proposed program to the general field. This abstract may be used for external reporting and should provide a concise programmatic overview.

The focus of this Master's Degree Program is Artificial Intelligence in Medicine, which is defined as the application of computational methods and machine learning techniques to the analysis of medical problems. The intended audience of this Master's Program is graduate students in Bioengineering or Public Health or healthcare professionals who are interested in earning advanced knowledge in the field of Artificial Intelligence and wish to be trained to apply these techniques to medicine. The program is intended to be one full year (Fall, Spring and Summer) for full-time students. The program emphasizes the mastery of skills required to analyze medical data related to patients and public health, which include big data, medical imaging, biostatistics, experimental data (clinical and laboratory), and healthcare information. The academic goals of the Master's Program are mastery of methods for efficient and precise analysis of medical data and biostatistics. The rationale for creating this Master's program is the benefits to healthcare gained through use of modern computational techniques to manage and investigate the ever-increasing volume of patient data and wide variety of diseases. Purely manual or empirical assessment is no longer adequate due to the large size and complex relationships embedded within these data. Students will acquire skills and knowledge in computation, modeling and simulation, machine learning, medical data management, and advanced statistical analysis, with an emphasis on interdisciplinary collaboration. The program's relationship to the general fields of engineering and public health is specialized training in the automated analysis of medical data and statistical information.

II. Educational Program Objectives - Description of the academic program, including:

- Objectives of the Program

The objectives of the program are to:

1. Train highly motivated graduate students who demonstrate advanced level AI expertise and practical experience necessary to analyze medical data related to patients and public health, which include big data, medical imaging, biostatistics, experimental data (clinical and laboratory), and healthcare information. (Advanced Knowledge and Life-long Learning)
2. Produce students with advanced skills in methods for efficient and precise analysis of medical data and biostatistics, knowledge in biostatistics and AI for employment in industry, academia or government, or further professional/graduate studies.

- Admissions requirements

Applicants must meet Speed School graduate admission requirements along with additional program requirements. Applicants must, as a minimum, have completed a Bachelor's Degree in engineering, mathematics, statistics, basic sciences, or related discipline from an accredited program. Successful applicants will typically have a 3.00 cumulative GPA in their BS degree. Applicants with an undergraduate GPA of 2.75 will be considered for provisional acceptance; however, they must maintain a 3.00 GPA at a minimum in their first year of study or they will not be allowed to continue in the program.

Students with basic science and public health backgrounds are encouraged to apply but may be asked to take pre-requisite courses. Students will need to have the follow pre-requisite coursework: calculus I-III with coverage through multivariable calculus (partial differentiation and multiple integration). In addition,

students are expected to have completed an introductory course in programming, such as BE 340 (Computational Methodologies in Bioengineering), PHST 301 (Quantitative Methods in Public Health) or equivalent.

Applicants must submit: 1) transcripts of all college-level courses; 2) a written statement by the applicant describing previous experience related to Artificial Intelligence in Medicine; 3) a statement as to how the Master's Program will allow them to fulfill their career goals; and 4) 2 letters of recommendation. Students whose native language is non-English, or degree is from a non-US accredited institution are required to submit TOEFL scores (administered by the Educational Testing Service). A minimum TOEFL score of 79 or higher on the internet-based test or 550 or higher on the paper-based test is required. Alternatively, a minimum of 6.5 on the International English Language Testing System will be accepted.

- Graduation requirements

Students must meet degree requirements established by the Speed School of Engineering, in addition to Program requirements. Students must complete the courses (30 credit hours) in the Master's Program with a 3.00 cumulative GPA or higher. Students must complete a minimum of 30 credits. All program requirements must be completed within six years from admission into the program.

- Curriculum—List of **new** courses to be developed (general description of anticipated new courses)

Two new courses (generically listed as BE 500 while their final number is determined), will be developed in the Bioengineering Department for the new Master's Program: Introduction to AI in Medicine, and Graduate Project in AI. The rest of the courses required for the program already exist in the Department of Bioengineering (BE) and the School of Public Health and Information Sciences. Twenty-four credit hours of coursework are considered to be core (mandatory) courses for the program. 6 hours of electives may be chosen from the list of approved electives. Twelve of the core course credit hours for the program are from classes offered in Public Health and the other twelve credit hours are offered from Bioengineering. Students may select their elective courses from either Department.

Course curriculum for students in the Master's Program:

Fall I:	
*Introduction to AI in Medicine (BE XXX, new)	3
*PHST 661	3
*Statistical Computing (PHST-620) – SAS programming	3
*Data Mining (PHMS-641)	3
Spring:	
Medical Image Computing (BE 542)	3
*Machine Learning in Medicine (BE 540)	3
*Data Mining II (PHMS-642)	3
Elective	3
Summer:	
*Graduate Project in AI in Medicine (BE 6xx, new)	3
Elective	3
TOTAL HOURS	30

Potential Electives:

Modelling of Biological Phenomena (BE 685)	3
AI techniques in digital pathology (BE 500/BE 544)	3
Computer tools for medical image analysis (BE 543)	3
Machine Learning in Python (BE 530)	3
Artificial Intelligence in Radiomics (BE 600)	3
Computational Methods for Medical Image Analysis (BE 640)	3

- Potential for collaboration with other units at UofL, and/or articulation with other institutions.

The program is built on a close collaboration between the Speed School of Engineering and the School of Public Health and Information Sciences within which the Bioengineering Department and Department of Biostatistics and Bioinformatics are each providing the unique expertise of their representative faculty. In contrast to the existing Certificate in Artificial Intelligence in Medicine, this collaboration between the Speed School of Engineering and the School of Public Health will greatly expand the appeal and reach of the program to a wide student base, including students interested in engineering and public health as well as health care professionals and computer scientists who wish to expand their skillset and earn an advanced degree in Artificial Intelligence in Medicine.

In addition, the Graduate Project in AI in Medicine course may give students an opportunity to work on projects in collaboration with researchers at the School of Medicine and Arts and Science. In particular, BE faculty have established collaborations with the Cardiovascular Innovation Institute, the Kentucky Spinal Cord Injury Research Center, the Brown Cancer Center, the Center for Predictive Medicine, and the Departments of Oncology and Radiology. Faculty in the Department of Bioinformatics and Biostatistics have a long history of collaboration with the same groups above as well as faculty in School of Arts and Sciences including the Departments of Mathematics and Psychology.

III. Linkage with the Mission and Strategic Plan. Describe how the proposed program supports the university and unit mission/strategic plans.

Establishing this Master's Program will address several goals of the University's Strategic 2023-2025 Plan and the 21st Century Initiative. Specifically, as related to the relevant goals/actions stated in these initiatives, the Master's program will:

University 2023-2025 Strategic Plan

1. Create interdisciplinary degrees and credentials driven by community, society, and workforce needs.
2. All students will be provided with a foundation of essential skills that each recognizes as translational to career, professional and life opportunities.

University 21st Century Initiative

1. Revenue Enhancement: "Strategically grow enrollment in high demand fields".

In addition to these university-wide goals, this Master's program will also address several goals outlined in the JB Speed School of Engineering 2023 Strategic Plan:

1. Establish areas of research excellence in engineering human health and cyber enabled discovery
2. Attract motivated, prepared, and talented students into all Speed engineering degree programs
3. Provide a wide variety of outstanding experiential learning experiences
4. Engage students with state-of-the-art accredited engineering curricula
5. Greatly increase the national and international recognition of Speed School research activities

IV. Diversity and Inclusion

The Master's program will promote accessibility and equity for strategic populations through outreach of both departments' faculty and staff to engage potential rising undergraduates and graduate students to make them aware of the opportunities available for advanced degrees in AI in medicine. This includes annual outreach sessions at local high schools in underserved communities, departmental representation in the Brown Forman Engineering Academy, and participation in Diversity Week at the University. We also plan outreach to present the program to Identity-based student organization chapters such as the American Society of Engineers of Indian Origin (ASEI), National Society of Black Engineers (NSBE), Society of Hispanic Professional Engineers (SHPE), Society of Women Engineers (SWE), and Speed Spectrum chapters at UofL. Additionally, all faculty and staff involved in the program are expected to attend University trainings such as Green Dot, Implicit Bias, and Microaggressions training.

V. **Student Demand**. Specify evidence of student demand and projected enrollments for the first five years of the program. Based on the enrollment projections, indicate the projected revenues. Provide a description of how the tuition projections were calculated.

	Year 1	Year 2	Year 3	Year 4	Year 5
Full-Time	3	6	10	14	18
Part-Time	2	4	5	6	7
Projected tuition revenue	$87,750	$180,765	$278,983	$382,932	$492,867

Based on similar programs (University of Wisconsin – Madison and University of Washington – Seattle) across the country, their existing faculty resources during the first five years of the program, as well as expected enrollment by students residing internationally, we project an initial enrollment of 3-5 students, with the number of students admitted and enrolled increasing yearly by this same number. The first graduates are expected at the end of the first year of the program. Thus, an enrollment of approximately 15-25 students is projected by Year 5, yielding annual tuition revenue reaching approximately $492,867, calculated as follows. The Bioengineering program currently offers a certificate program in AI in Medicine. While the initial enrollment numbers have not been as high as anticipated, we believe this to be related to economic factors during the COVID-19 pandemic ongoing when the certificate program was started. As the economy recovers, we anticipate that enrollment in the certificate program will increase. Additionally, we believe the Master's in AI in Medicine program will have broader appeal to both national and international students since as it is an advanced degree that will yield greater returns for students who complete the program. In terms of students in the certificate program, they may be able to apply some of their course credits to the Master's program if these credits are applicable to the Master's degree.

The program requires students to complete 30 credit hours, with each credit hour generating revenue of $775/credit hour (resident) and $1575/credit hour (non-resident). We used 75% of these values to calculate the return of tuition revenue to Speed School. The projected tuition revenue is conservatively estimated by calculating it at the resident student rate for full time students and non-resident rate for part time students and assuming a 3% yearly inflation-related increase in tuition.

VI. Market Demand

1. Describe the intellectual, artistic, cultural, social or economic need for the program. Workforce

objectives or employment opportunities should be clearly delineated. Evidence of market demand is essential. Please also provide source for market demand information.

The field of computation and, in particular, machine learning, has experienced a renewed interest in the past five years with the advancement of deep learning and artificial intelligence technologies. The confluence of increased computer hardware capabilities, e.g., via GPU architectures, and the advancement of computational algorithms, are opening up a broad application of such technologies in a diversity of fields, including transportation, retail business, medicine, and telecommunications. Consequently, most major universities in the U.S., including the University of Louisville, have implemented machine learning certificate programs, including Stanford, Harvard, Cornell, and Johns Hopkins. We believe that the next step in evolution for advanced degrees in Artificial Intelligence will be Master's programs such as the one in the current proposal. In light of this driving force, more advanced degrees in Artificial Intelligence are developing rapidly, such as those offered at Campbellsville University and the University of the Cumberlands. The number of employment opportunities has correspondingly mushroomed, with the projected growth of jobs for computer and information research scientists expected to grow 19% within the next 9 years, according to the University of California, Irvine (https://ce.uci.edu/areas/it/machine_learning/). Additionally, certificate programs are also being offered by large companies driving this innovative field, including IBM and Google.

Artificial intelligence and computation applied to medicine and medical data analysis represent a subset of this activity. Importantly, Artificial Intelligence is the technology that enables human-like behavior to be mimicked by machines, such as reasoning and logical deduction. This technology can enhance the insight and understanding of complex inter-related medical information such as genomics, transcriptomics, metabolomics, clinical biomarkers, medical imaging, etc. Mathematical modeling and simulation, machine learning, and statistical analyses can all be part of AI technology, which goes beyond each of these traditional approaches. For example, the training of AI algorithms with large medical data sets allows for discovery of correlations and predictions of future occurrences and their understanding in ways that may not be possible with simple data mining technologies. A Google search for Master's Programs in Artificial Intelligence in Medicine currently yields 22 related programs, with 5 devoted to medical data analysis (Lightcast Q4 2022 Data set, www.economicmodeling.com). These programs achieved 175% growth between 2017 and 2022, with 116% growth in completion rate. Target occupations for this type of advanced degree reached 107,214 annual openings in 2020 with an attractive average salary of $118.2k/yr. These numbers, while promising, represent what we believe is just the beginning of an explosion of opportunity in the Artificial Intelligence sector and specialization in the analysis of medical data represents an under-developed potential. Our aim is to place the University of Louisville at the international forefront of Artificial Intelligence in Medicine. In the past five years, the volume of data has exploded. The collection of patient information from electronic medical records and connected medical devices (e.g., wearable monitors) requires integration and analysis. Significant increases in the number of programs that address the computational analysis and understanding of big data clearly indicate the student demand for such programs, mirroring the rapid adoption of these techniques for the medical field.

The state of Kentucky represents an underdeveloped market for Artificial Intelligence, as represented by no Master's Program completions in AI between the years 2017-2022 (Lightcast Q4 2022 Data set, www.economicmodeling.com). This shows a great opportunity for the University of Louisville to serve as a regional leader in the field of artificial intelligence focusing on medicine. Despite the lack of AI graduates, 2221 students in Kentucky earned Master's degrees in related fields such as Computer/Information Technology Services, Information Technology, and Computer Engineering. As the field of Artificial Intelligence in Medicine matures over the next decade we plan to harvest the interest in advanced degrees to help UofL become a leader in this field.

Obtaining the proposed Master's degree will enhance a student's engineering skillset in a demonstrable manner, specifying the ability to perform at a highly specialized level in the computational analysis of medical data. Additionally, students who are specializing in analysis of bioinformatics and biostatistics will gain knowledge of cutting-edge techniques for data analysis within the medical field. A recent search on www.glassdoor.com for regional job opportunities yielded 575 job openings for Machine Learning Engineers and Artificial Intelligence Engineers with a projected growth of 180%. Please see appendix A for current employer demand numbers and references.

VII. Employer Demand. If the program is designed for students to enter the workforce immediately, please complete the table in Appendix A at the end of this template.

The program is designed for students to enter the workforce immediately upon completion. The Master's degree augments a student's current academic or professional pursuits by enhancing their skills to analyze biomedical data via modeling and computational tools or parse bioinformatics and biostatistics information using cutting edge techniques in machine learning and artificial intelligence. Machine Learning was ranked as the number 1 top emerging position in 2020 and 2021 by LinkedIn's emerging job trend report and remains in 4th place in 2022 (https://www.linkedin.com/pulse/linkedin-jobs-rise-2022-25-us-roles-growing-demand-linkedin-news).

VIII. Academic Demand

1. If this is not a program that is designed for students to enter the workforce immediately after graduation, please indicate the skills that graduates will attain, the types of graduate programs the graduates are most likely to attend, and the types of jobs graduates will eventually seek.

   This Master's program provides an area of specialization for students currently pursuing a professional degree. For students who are already in the workforce, the Master's offers an opportunity for professional enhancement to acquire new skills or promote an established career. The skills attained include the ability to analyze biomedical data, biostatistics and bioinformatics via modeling and computational tools, such as machine learning. Graduates seeking employment may seek positions that require skills for the automated analysis of biomedical data in applied medicine or public health sectors, as may occur with health care, insurance, pharmaceutical, and laboratory employers. Additionally, no similar program M.S. exists in the region that combines artificial intelligence and medical applications to meet the academic demand of undergraduate students at UofL in Bioengineering or basic sciences seeking Master's degrees in Artificial Intelligence in Medicine.

2. Note if the proposed program replaces another program on campus.

   This program does not replace another program on campus.

In the table(s) below, provide information about similar programs in Kentucky based on CIP codes. Institutions may list other programs that are similar but may be classified in a different CIP code. A search for similar programs by CIP can be conducted at https://dataportal.cpe.ky.gov/KYAcademicProgInventory.aspx. Please contact the Program Approval and Review Coordinator, Leslie Harper, for assistance in determining a CIP code.
Copy the table below as needed to address all similar programs.
Note: Although this information is required by CPE for degree programs, certificate programs should also complete this table so that they can better consider how competition will affect enrollment projections.

Similar Program 1:	15534
Institution:	Campbellsville University
Program Name:	Master's Data Science Artificial Intelligence
Comparison of Objectives/Focus/Curriculum to Similar Programs: *Explain the differences in curriculum, focus, and/or objectives. If the proposed program curriculum does not differ substantially from existing programs, then describe potential collaborations with other institutions.*	The Campbellsville program focuses on using artificial intelligence for decision making in business applications. Since our program focuses on AI in health, we believe there will not be substantial overlap between the programs.
Comparison of Student Populations*: Describe how your target student population is different from those at other institutions and explain how your program reaches this new population (e.g., the proposed program is completely online while other programs are face-to-face or hybrid).*	This program focuses on recruiting international students who already have Master's of Science in Computer Science. Campbellsville also focuses on its mission of preparing Christian servant leaders. Our program will focus on graduate students in Bioengineering or Public Health who are interested in earning advanced knowledge in the field of Artificial Intelligence and wish to be trained to apply these techniques to medicine.
Access to Existing Programs: *Explain how/why existing programs cannot reach your target population and/or provide evidence that existing programs do not have the capacity to meet current student demand (e.g., the number of students on enrollment waiting list).*	The Campbellsville program does not focus on AI in medicine and offers no classes that focus on Medicinal aspects of big data and AI. We believe that for this reason the Campbellsville program would not be able to address our target student population.
Feedback from Other Institutions: *Summarize the feedback from colleagues at institutions with similar programs.*	

Similar Program 2:	14589
Institution:	University of the Cumberlands
Program Name:	Master's Global Business with Blockchain Technology; Artificial Intelligence in Business
Comparison of Objectives/Focus/Curriculum to Similar Programs: *Explain the differences in curriculum, focus, and/or objectives. If the proposed program curriculum does not differ substantially from*	The University of the Cumberlands degree focuses on business majors who wish to learn Artificial Intelligence as it applies to block chain and global business.

existing programs, then describe potential collaborations with other institutions.	
Comparison of Student Populations: *Describe how your target student population is different from those at other institutions and explain how your program reaches this new population (e.g., the proposed program is completely online while other programs are face-to-face or hybrid).*	The University of the Cumberlands degree focuses on business majors while our proposed program focuses on engineering and public health students.
Access to Existing Programs: *Explain how/why existing programs cannot reach your target population and/or provide evidence that existing programs do not have the capacity to meet current student demand (e.g., the number of students on enrollment waiting list).*	This program cannot address the objectives/target students of our program as it is not related to AI in medicine
Feedback from Other Institutions: *Summarize the feedback from colleagues at institutions with similar programs.*	

IX. Funding Sources

1. Will Additional Faculty be required?

   No

2. **Faculty Workload.** Describe the impact on current faculty workloads. How will the new program be supported based on current faculty effort?

   Primary coursework for the Master's Program will be from the BE and Bioinformatics and Biostatistics departments current course offerings. However, increases in course enrollment anticipated in Years 3-5 may require additional sections of program courses to be offered, leading to an increase in faculty workload.

3. **Budgetary rationale**. Provide the financial rationale or benefit to creating this new program. Explain how the program will be funded, what other programs will be affected, and why this program is considered both an efficient and effective use of funds.

   Since this Master's Program is financially integrated with the current graduate programs in BE and Public Health, the program does not require additional funding to initiate. Most program courses are already available and being offered and the 2 new required courses can be developed using the expertise of existing faculty. No other programs are expected to be affected. The proposed program is considered an efficient and effective use of funds because it does not require additional funds to be initiated. As the program grows we will request one graduate teaching assistant (beginning in year 3) to assist with the greater course workload.

4. **Please provide a reasonable estimate of program expenditures related to marketing and outreach, as well as expenditures incurred by additional personnel needed to provide faculty training and/or assistance with instructional design.** This estimate should include expenditures incurred by other administrative units (e.g., Delphi Center for Teaching & Learning). Note that although this program will not bear the full burden of additional personnel in other administrative units, these costs should be considered.

   In consultation with the Delphi Center, we believe that the proposed program will not cause any costs to the Delphi Center as the faculty involved in the program have already been trained for producing and providing online course content and will continue to attend regularly offered training already provided by the Delphi Center.

5. **Financial Resources and Program Impact**. The LOI should be developed without the expectation of special financial agreements with the provost. If no internal allocation or reallocation has been committed to the new program, leave that row blank. Projected tuition revenues should go in the "Other revenues" row of the table (and label it as tuition).

   There is no expectation of special financial agreements with the provost. No internal allocation or reallocation has been committed to the program.

Projected Revenues	Year 1	Year 2	Year 3	Year 4	Year 5	Five-year Total
General Funds (internal reallocation)	0	0	0	0	0	**0**
Grants or Gifts, list each one	0	0	0	0	0	
Other revenues (Tuition)	$88k	$181k	$279k	$383k	$493k	**$1.4M**
Total Projected Revenues	$88k	$181k	$279k	$383k	$493k	**$1.4M**

Please see Section V for methods of calculating other revenues.

6. **New Resource Requirements** – Describe the need for any new or additional resources necessary to implement the proposal. Document the expected cost/expenditures in a table.

Projected Expenses	Year 1		Year 2		Year 3		Year 4		Year 5		Five-year Total	
	#	Cost $	#	Cost $	#	Cost $	#	Cost $	#	Cost $	#	Costs $
Faculty Lines (full-time, adjunct or part-time faculty)												

Graduate Assistant Positions					1	$50,244	1	$51,752	1	$53,304	1	$155,301
Library Support		$6550										**$6650**
Facilities, technology or equipment												
Other (please describe below the table)*												
Total Projected Expenses		**$6650**				$50,244		$51,752		$53,304		$161,951

- Faculty (full-time, adjunct or part-time faculty)

None expected.

- Graduate teaching assistants

One graduate teaching assistant will be requested as the program grows in enrollment. Projections are based on Resident tuition rates.

- Library support

The library has requested $6550 in the first year of the program to purchase subscriptions for 4 journals deemed relevant to the program during the library evaluation. The courses of the program are currently supported by the Ekstrom (Main) and Kornhauser Libraries which house over 2.1 million volumes, approximately 16,000 current journal subscriptions, special collections, media and microforms. In addition, the library has an on-line virtual library that provides faculty, staff and students access to over 20,000 full text electronic journals, inter-library loan services, electronic books and databases, reference materials and other library resources. The library resources are more than adequate to support the needs of the faculty and students in the proposed Master's Program.

- Facilities, technology or equipment

No additional facilities, technology or equipment are required for this program.

Offices - The Bioengineering Department is located on the University of Louisville Belknap campus in Lutz Hall, which contains the department office, two teaching classrooms, two instructional laboratories, a conference room, and faculty research laboratories. Offices for faculty and staff are in buildings across the Belknap Campus (Lutz Hall and Shumaker Research Building) and Health Sciences Campus (Cardiovascular Innovation Institute, Clinical Translation Research Building and Health Sciences Research Tower). Department and faculty offices for other Speed School of Engineering departments are in Ernst Hall (Chemical Engineering), Duthie Center (Computer Engineering & Computer Science), J.B. Speed Building (Industrial Engineering), Sackett Hall (Mechanical Engineering), W.S. Speed Building (Electrical & Computer Engineering).

The School of Public Health and Information Sciences (SPHIS) is located on the Health Sciences campus. All faculty offices for faculty involved in this proposed joint degree program are in the SPHIS building and, there are three available classrooms and a computer lab.

Classrooms and Instructional Laboratories – The program-specific courses are offered primarily in Lutz Hall. All classrooms have adequate lighting, climate control and acoustic characteristics, and are equipped with computers that interface with overhead LCD projectors. All buildings on the Belknap Campus are equipped with wireless internet access.

Computing Resources - The University of Louisville central research computing or Cardinal Research Cluster (CRC) is housed in the UofL Information Technology Data Center located in the Miller IT Center on the university's Belknap campus. This facility provides over 5000 square feet of secure, environmentally controlled data center space including a FM200 fire suppression system. The data center is fed by 1000kVA electrical service with backup power provided by a large UPS and an 1125 kVA diesel generator. The research cluster is equipped with its own dedicated in-row cooling systems and utilizes cold aisle containment to improve cooling efficiency. The facility is physically secure with limited keycard access and is monitored 24 hours a day. The UofL CRC infrastructure became available in spring 2009 and was upgraded in spring 2011. This infrastructure includes multiple systems serving the research needs of the entire university, including a general-purpose high-performance distributed-memory computation cluster, a high-memory SMP system and several general-purpose web and software servers. The general-purpose compute cluster is composed of 312 IBM iDatplex nodes each equipped with two Intel Xeon L5420 2.5 GHz quad-core processors for a total of 2496 processor cores. Each node has 16 or 32 GB of memory, and the node interconnects are a mixture of Gigabit Ethernet (1Gbps) and InfiniBand (16 Gbps) technology. The cluster is estimated to have a peak performance rating of 20+ TFLOPS. The University of Louisville's campuses are served by a 40 Gigabit per second (Gpbs) campus backbone network. This backbone is comprised of over 80 miles of fiber in a dual ring configuration. The wired network can provide 100Mbps and 1Gbps Ethernet service for faculty and staff communications needs. With the recently completed Pervasive Wireless Project, the U of L campus wireless network provides 802.11n wireless connectivity to wireless devices at speeds up to 300Mbps. This wireless connectivity is available across all of U of L's campuses, classrooms, and buildings. The University of Louisville is connected to the Internet2 node via dedicated 10Gbps optical fiber backbone network. The Internet2 connection provides the University of Louisville direct, high bandwidth, access to national research and education networks such as XSEDE/Teragrid. The University of Louisville is also a member of the Kentucky Regional Optical Network (KyRON). This regional optical network is managed and operated through a consortium including the University of Louisville, the University of Kentucky, and the Kentucky Council on Postsecondary Education. Participating universities are interconnected using 10Gbps optical links. The Kentucky RON extends the research data sharing capabilities of the University of Louisville with other participating universities throughout the state and provides new opportunities for collaboration.

Multi-Disciplinary & Core Research Facilities - To support the training of students in state-of-the-art methodologies and techniques, Program students will have access to several multidisciplinary and core research facilities, as well as to individual faculty laboratories. Specifically, students will have access to the multi-disciplinary Bioinformatics Laboratory.

The Bioinformatics Laboratory is housed in the CECS department in room 238 of the Duthie Center. The facilities include a: visualization wall consisting of an assembly of 3x6 Dell monitors and used to visualize complex images; video conferencing system; powerful computers including Dell precision T7400 (8 processors, 20 gb RAM, 2 TB HDD, NVIDIA card) and Dell Alienware computers (8 processors, 12 GB RAM, 1 TB HDD, NVIDIA card); library with bioinformatics and related fields books; and, panaboard (Panasonic White board) that can take pictures of the discussion and can be saved and printed from computer.

- Other, please describe:

None

X. Online Delivery

Academic units wanting to create <u>new</u> online degrees or certificates will be required to complete the following section demonstrating that the program will meet the criteria for online programs at UofL. If you cannot agree to the terms outlined, please make a case for why you cannot or should not agree to certain elements, although the reasons must be substantiated with evidence. Units wishing to create a program that is not online do not need to complete this section

1. **Distance Education (describe plans)**

   The full program is expected to be offered as a hybrid degree with both in person and online options. All the courses in the program are expected to be offered online by the time the program starts can be completed by distance education students subject to the same admission and graduation requirements as in-class students.

2. **Library Resources.** Are adequate library resources available to support an online version of your program? Please provide a letter from the Dean of Libraries addressing their ability to support the program.

   The Dean of libraries has examined the proposed program and has offered his support. Please see the attached letter for his summation of the expected library contribution to the program.

3. **Please complete Appendix A.**

4. **Online Program Best Practices**

   Please indicate whether the academic unit will design the program in accordance with the fo**l**owingbest practices for online programs by placing an "X" in the appropriate column. Please give serious consideration to each recommendation understanding that online programs are primarily intended for adults who are working, have a family, or other potential commitments or circumstances that would make it difficult to attend a program on campus or a program with designated meeting times.

Yes	No	Online Program Best Practice
	x	8-week courses *For undergraduate programs, this would be major classes at a minimum*

		although also recommended for general education classes
x		Allow part-time enrollment
x		Admit students at least two times/year
x		Asynchronous classes (no regular required meeting times)
x		100% online (in-person experiences that can be done off-site do not affect this factor, meaning it would still be considered 100% online even if the student has to do in-person assignments where they live)
x		Graduate-level programs will not require the GRE, GMAT or other standardized tests for admission

5. Quality Program Practices

Please indicate whether the academic unit will design the program in accordance with the following best practices for online programs by placing an "X" in the appropriate column.

Yes	No	Quality Program Practice
x		Require all faculty who will be developing and/or teaching in the program to go throughDelphi U or have gone through an equivalent training
x		Require all faculty developing online courses to partner with an instructional designer in theDelphi Center and adhere to established deadlines for course creation

The department of Bioengineering plans, upon initiation of the proposed program, to work with the Delphi Center to incorporate current best program practices into the online content for the MS in AI in Medicine and ensure that the online delivery meets the high expectations of the University.

6. Academic units that cannot agree to recommendations in Sections 3 and 4 above should explain why and provide substantiation.

Stipulations that will be difficult to implement with the planned curriculum:

8-week courses
For undergraduate programs, this would be major classes at a minimum although also recommended for general education classes

The classes for this Master's Program are already offered at the University and would require significant modifications to reduce to 8 week classes. Additionally, the curriculum is designed to fit a 3-semester format with full Fall, Spring and Summer terms.

Appendix A. Employer Demand.

1. If the program is designed for students to enter the workforce immediately, please complete the following table (see resources below the table)

2. Please provide source of employer demand information and time frame for the projections:

Type of Job	Regional Avg Wage	Regional # of openings	Regional Growth Projections (%)	State Avg Wage	State # of openings	State Growth Projections (%)	National Avg Wage	National # of openings	National Growth Projections (%)
Machine Learning Engineer	**$49k-$201k**	**195**	**344**	**$49k-$201k**	**39**	**344**	**$146k**	**4604**	**344**
Artificial Intelligence Engineer	**$49-153k**	**380**	**16**	**$49-153k**	**51**	**16**	**$66k-165k**	**7062**	**16% (through 2028)**
Artificial Intelligence Target Occupation				**$91k/yr**	**620**	**-3.6%**	**$118k/yr**	**107k**	**2.6%**

Employer Demand Resources:
Regional searches were performed on glassdoor.com using Kentucky, Indiana, and Ohio as regional examples.
https://www.glassdoor.com/Job/kentucky-ai-machine-learning-engineer-jobs-SRCH_IL.0,8_IS1141_KO9,37.htm
https://onlinedegrees.sandiego.edu/machine-learning-engineer-career/
https://www.computersciencedegreehub.com/faq/how-is-the-career-outlook-for-artificial-intelligence-jobs/
https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm#tab-6

Please note the timeframe for the projections.

Gray Associates PES+ (Please contact Leslie Harper if you do not have the username and password and for assistance in determining a CIP code.)
Bureau of Labor Statistics' Occupational Outlook Handbook
Kentucky Center for Statistics
Kentucky, Bridging the Talent Gap
Document - https://www.bridgingthetalentgap.org/wp-content/uploads/2017/05/KY-Statewide.pdf

Interactive website: https://bridgingthetalentgap.org/dashboards/