Overview

Artificial intelligence (AI) will continue to revolutionize many industries, for example, driverless cars, finance, national security, medicine, e-commerce, to name a few. President Rafael Reif stated in a recent article, “To prepare society for the demands of the future, institutions must equip tomorrow’s leaders to be ‘AI bilingual’. Students in every field will need to be fluent in AI strategies to advance their own work. And technologists will need equal fluency in the cultural values and ethical principles that should ground and govern the use of these tools.” ¹ This course will equip MIT graduate engineering students to lead, develop, and deploy AI systems in ways that augment human’s capabilities, while providing positive impact to society. It will teach at the intersection of engineering leadership and artificial intelligence, and deliver learning experiences in ways that are informed by research but applied to engineering products and/or services.

The course will begin with a brief AI history, including highlights of representative successes in the application of AI. The course will be project-based requiring the students to formulate a strategic roadmap of an innovative AI application. Several key engineering leadership principles will serve as the foundation for developing an AI application roadmap. These principles will include establishing a strategic vision, identifying candidate customers, project execution, and the building of teams with complementary strengths. The students will be required to present the strategic vision and roadmap proposal to a selected industry/academic panel with a broad range of expertise. The final presentation will require a balance between technical depth and breadth, as well as emphasis on strategic vision and uniqueness of the AI application. The course will also include invited speakers from industry that are practitioners in the development and deployment of AI applications. At the completion of this course, the students will have the necessary skills to lead AI teams. This course is offered through the Gordon-MIT Engineering Leadership Program.

Course Units: 12 credits, 3-0-9

¹ L. Rafael Reif, February 10, 2019, “Prepare students for a future of artificial intelligence,” Financial Times.
Recommended Readings *(A subset will be required and identified during class)*

6. Key papers on AI system architecture subcomponents will be recommended throughout the course.
7. Key papers on Engineering Leadership will be recommended throughout the course.
8. Readings will also be posted to Stellar.

**Learning Objectives**

At the completion of this course, students will be able to lead AI teams based on four core competencies:

- Understanding an end-to-end AI architecture at the system engineering level
- Applying engineering leadership principles
- Creating a strategic vision and development plan focused on a product or service
- Developing an execution strategy staffed by a diverse and multidisciplinary team
- Demonstrating an AI conceptual design based on an industry challenge problem using the Raspberry Pi

**Exams**

There will be three exams consisting of multiple-choice and true/false questions. These will be administered in class and will be based on assigned readings, lectures, and class discussions. These will be closed-book, closed-note exams.

Make-up exams will be administered only under circumstances involving serious and documented illnesses, or other excused absences. If such circumstances occur, students must inform us immediately in order to coordinate a make-up exam. Documentation for excused absences will be required.

**Team Projects and Presentations**

The purpose of these projects is to help students develop a practical understanding of how to apply course concepts to real, client-based problems. Small groups will be formed early in the semester to focus on specific AI application problems from two companies (one entrepreneurial company and one large company). We will provide some time in class for students to work on these problems but we also anticipate students will work together outside of class. Teams will prepare two presentations; one to class peers for feedback purposes, and a final presentation to a panel of industry and academic experts.
There will be three deliverables for the class project, at the end of the semester, as part of the experiential learning element of the course:

1. An AI strategic roadmap addressing one of the two companies challenge problems. This strategic roadmap will stress all elements of engineering leadership, except project development.

2. An AI conceptual design demo showing key capabilities of your team solution to the company challenge problem. This part will address project development suitable for a 1 semester class.

3. A document that will be handed over to one of the two companies at the conclusion of the class containing: a) hard copies of the slides, b) a jupyter notebook file containing the procedure you use to execute the demo

**Class Participation**

Students will be expected to actively contribute to class discussions and to honor that group project obligations. Class participation grades are based on participation, attendance, and results of a final peer and industry/academic panel presentation. Additional information about grading will be provided in class and final grades for class participation will be determined after the last day of class.
Areas Covered in the Course are Based on the Following Framework:

Engineering Leadership in the Age of AI
- Areas Covered in 6.976 Course -

Engineering Leadership Principles
- Strategic vision
- External relationships
- Internal execution
- Recruiting / mentoring AI talent
- Technical depth and breadth
- Ethics in AI

Invited Speakers and Panel Discussions

Human-Machine Augmentation
Confidence Level vs. Consequence of Actions

AI Architecture
- Data Conditioning
- Machine Learning
- Human-Machine Teaming
- Modern Computing
- Robust AI

System Engineering Approach

Project-based Conceptual Design

Invited Speakers and Panel Discussions

http://web.mit.edu/gordonelp Twitter: @ELAAI16

8/26/2019

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The AI Canonical Architecture is Central to the Course Content:

**AI Canonical Architecture**

- **Sensors**
  - Structured Data
- **Sources**
  - Unstructured Data
- **Data Conditioning**
  - Information
- **Machine Learning**
  - Unsupervised Learning
  - Supervised Learning
  - Transfer Learning
  - Reinforcement Learning
  - Etc.
- **Human-Machine Teaming (CoA)**
  - Human
  - Human-Machine Complement
  - Machine
  - Spectrum
- **Users (Missions)**

**Modern Computing**

- CPUs
- GPUs
- TPU
- Neuromorphic
- Custom
- Quantum

**Robust AI**

- Explainable AI
- Metrics and Bias Assessment
- Verification & Validation
- Security (e.g., counter AI)
- Policy, Ethics, Safety and Training

**GPU** = Graph Processing Unit
**TPU** = Tensor Processing Unit
**CoA** = Courses of Action

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Final Grading Breakdown:

| Individual contributions based on three exams | 40% |
| Class participation | 20% |
| Final team project and presentations | 40% |
| Total | 100% |

Major Assignments, Exams, and Dates

1st Exam focused on fundamentals of AI architecture 10% September 23rd
2nd Exam focused on subcomponents of AI architecture and engineering leadership principles 10% October 16th
Class participation 20% November 20th Peer presentation of AI conceptual design and development plan of a product or service November 25th
3rd Exam focused on bringing it all together: engineering leadership and end-to-end AI architecture 20% December 2nd and December 4th
Final presentation of AI project 40%
Total 100%
<table>
<thead>
<tr>
<th>Lecture #</th>
<th>Class Date</th>
<th>Topic</th>
<th>Description</th>
<th>Major Events Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 Sept</td>
<td>Introduction and engineering principles</td>
<td>Overview course content and present key AI accomplishments plus introduction to engineering principles</td>
<td></td>
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<tr>
<td>2</td>
<td>9 Sept</td>
<td>AI canonical architecture</td>
<td>System engineering approach to developing an AI product or service</td>
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<tr>
<td>3</td>
<td>11 Sept</td>
<td>Data conditioning</td>
<td>Unstructured and structured data</td>
<td>Misty Robotics invited speaker</td>
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<td>4</td>
<td>16 Sept</td>
<td>Machine learning algorithm taxonomy</td>
<td>Classes of ML algorithms and examples of successful implementations</td>
<td>Start identifying teams to work on class project</td>
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<tr>
<td>5</td>
<td>18 Sept</td>
<td>Modern computing as enabling technology</td>
<td>Types of computing engines and key computational drivers. Review of key concepts prior to exam</td>
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<tr>
<td></td>
<td>23 Sept</td>
<td>Exam focused on subsystem components of AI architecture</td>
<td>Exam addressing data conditioning, ML algorithm taxonomy and modern computing</td>
<td>1st Exam</td>
</tr>
<tr>
<td>6</td>
<td>25 Sept</td>
<td>Robust AI</td>
<td>Key issues in making AI systems robust. Confidence in a machine making a decision vs. consequence of action</td>
<td>Bose Wellness Division invited speaker</td>
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<tr>
<td>7</td>
<td>30 Sept</td>
<td>Human-machine teaming</td>
<td>Human-machine teaming as an enabler to augmenting human capabilities</td>
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<tr>
<td>8</td>
<td>2 Oct</td>
<td>Overview of engineering leadership principles</td>
<td>Strategic development model and development plan for a product or service</td>
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<tr>
<td>9</td>
<td>7 Oct</td>
<td>Tools and techniques in formulating a strategic vision</td>
<td>Internal and external factors in formulating a strategic vision</td>
<td>Finalize class teams</td>
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<tr>
<td>10</td>
<td>9 Oct</td>
<td>External relationships</td>
<td>Forming teams and understanding customer needs. Review of key concepts prior to exam</td>
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<tr>
<td></td>
<td>16 Oct</td>
<td>Exam focused on additional subsystem components of AI architecture and engineering leadership principles</td>
<td>Exam addressing AI architecture and material covered so far on engineering leadership principles</td>
<td>2nd Exam</td>
</tr>
<tr>
<td>11</td>
<td>21 Oct</td>
<td>Internal execution and managing-by-results</td>
<td>Measuring what matters and fostering a culture of innovation</td>
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<tr>
<td>Date</td>
<td>Day</td>
<td>Topic</td>
<td>Description</td>
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<tr>
<td>12 Oct</td>
<td>23</td>
<td>Effective recruiting and mentoring AI talent</td>
<td>Importance of diverse and multidisciplinary AI teams. Personal board of advisors</td>
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<tr>
<td>13 Oct</td>
<td>28</td>
<td>Leading from a position of strength in technical depth and breath</td>
<td>Discussion on balance between technical depth and breadth</td>
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<tr>
<td>14 Oct</td>
<td>30</td>
<td>Tools and techniques in formulating a strategic development plan</td>
<td>Show examples of strategic development plans integrating engineering leadership principles</td>
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<tr>
<td>4 Nov</td>
<td></td>
<td>Ethics in AI</td>
<td>Panel discussion on ethics in AI</td>
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<td>15 Nov</td>
<td>6</td>
<td>AI tools and techniques leveraging AI open ecosystem</td>
<td>Work through an example using existing AI tools and techniques</td>
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<tr>
<td>13 Nov</td>
<td></td>
<td>Preliminary AI conceptual design for a product or service</td>
<td>Team exercise applying strategic development model to formulate an innovative product or service (part I)</td>
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<tr>
<td>18 Nov</td>
<td></td>
<td>Refine AI conceptual design and development plan for a product or service</td>
<td>Team exercise applying strategic development model to formulate an innovative product or service (part II)</td>
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<tr>
<td>20 Nov</td>
<td></td>
<td>Peer presentation of development plan for an AI conceptual design for a product or service</td>
<td>Presentation of AI conceptual design and development plan to class peers and receive feedback (~15 min/team)</td>
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<tr>
<td>25 Nov</td>
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<td>Exam focused on bringing it all together</td>
<td>Applying engineering leadership principles to the development of an AI products or service</td>
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<tr>
<td>16 Nov</td>
<td>27</td>
<td>Tools and techniques for quantifying AI system capabilities</td>
<td>Discussion on quantifying an end-to-end AI system capability</td>
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<tr>
<td>2 Dec</td>
<td></td>
<td>Final presentation of AI conceptual design (Group 1)</td>
<td>Presentation of AI conceptual design (including development plan) to industry/academic panel (~20 min/team)</td>
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<tr>
<td>4 Dec</td>
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<td>Final presentation of AI conceptual design (Group 2)</td>
<td>Presentation of AI conceptual design (including development plan) to industry/academic panel (~20 min/team)</td>
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<td>3rd Exam</td>
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<td>Invite industry/academic panel</td>
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<td></td>
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<td></td>
<td>Invite industry/academic panel</td>
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</table>
Review of core competencies (part I)  
Review course takeaways: end-to-end AI architecture, engineering leadership principles, and team projects (part I)

Review of core competencies (part II)  
Review course takeaways: strategic vision, development plan, execution strategy, and team projects (part II)

Supplemental Readings on AI Canonical Architecture (required reading will be identified during class)
Supplemental Readings on Engineering Leadership (required reading will be identified during class)

**Academic Integrity**

MIT’s Academic Integrity policy reads, in part: “Fundamental to the academic work you do at MIT is an expectation that you will make choices that reflect integrity and responsible behavior. MIT will ask much of you. Occasionally, you may feel overwhelmed by the amount of work you need to accomplish. You may be short of time, working on several assignments due the same day, or preparing for qualifying exams or your thesis presentation. The pressure can be intense. On the “Working Under Pressure” page, we suggest resources to help you manage your workload and prevent yourself from becoming overwhelmed. However, no matter what level of stress you may find yourself under, MIT expects you to approach your work with honesty and integrity.” (see more information at [http://integrity.mit.edu/](http://integrity.mit.edu/)).

We expect to uphold these standards in our class and this is essential to your personal learning and to our ability to assess learning. Violating the Academic Integrity policy in any way (e.g., plagiarism, unauthorized collaboration, cheating, etc.) will result in official Institute sanction and please let us know if you have any questions about these issues. (Adapted from guidelines recommended by the MIT Teaching and Learning Lab at [http://tll.mit.edu/](http://tll.mit.edu/)).

**Students with Disabilities**

If you need disability-related accommodations, please let us know early in the semester. If you have not yet been approved for accommodations, contact the Student Disability Services at sds-all@mit.edu for more information. We look forward to working with you to assist with approved accommodations.

**Inclusive Learning**

MIT and GEL values an inclusive learning environment. We aim to create a sense of community in our class; a place where everyone will be treated with respect and where everyone feels safe to share their ideas and perspectives. We welcome individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations – and other visible and nonvisible differences. Participants are expected to contribute to an open and inclusive environment for every other participant. If you feel this standard is violated or moving in this negative direction, please let us know (Adapted from guidelines recommended by the MIT Teaching and Learning Lab at [http://tll.mit.edu/](http://tll.mit.edu/)).