MEng Design Project Announcement – 2017-18 AY

Project title: RF Signal Recognition with Machine Learning

Brief Description of Design Project Goals:

Overview: The goal of this project will be for students to investigate how to detect, recognize, and characterize unknown radio frequency (RF) communications signals by leveraging machine learning techniques. This is an important step towards the development of future cognitive radios that are able to autonomously establish a communications link and determine the best parameters to communicate in a congested electromagnetic spectrum, as well as providing an ability to monitor the electromagnetic spectrum and determine what other systems are operating in it. Advances in machine learning and software defined radio (SDR) have shown promise towards being able to solve this problem.

This project will ideally be a collaborative effort between Master’s Degree students in the Computing & Information Sciences Department and Electrical & Computer Engineering Department, with CIS students implementing machine learning approaches to partner with ECE students implementing the signal processing techniques for signal detection and modulation recognition.

Specific MEng Contribution: A library of RF signals with different types of modulation, bandwidths, and frequencies will either be generated or provided to the student project team. The team will be responsible for determining an approach to identify and characterize the different signals across an operating frequency band, and then implement that approach in software of their choice, such as MATLAB or Python. The team will develop and implement machine learning techniques to automatically detect and classify the signals. One set of known signals will be used for training the machine learning algorithms. A second set will then be used for testing how well the approach works on unknown signals.

Depending on the size, experience, and interests of the team, the project scope can go in a couple directions. One option is to use software defined radios (SDRs) to generate the library of RF signals, and actually send and receive RF signals as part of the data generation and collection. Another option is that MITRE can provide a recorded set of signals for the student team to use as the training set and unknown testing set.

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- Phone – 254-8984
- Office – 313 Phillips Hall

Outside Field Advisor Name: Matthew Kuzdeba, Kyle Harms (MITRE Corporation)
- Email - mkuzdeba@mitre.org, kyle.harms@cornell.edu
- Phone - 781-271-5647
Project Web Site:  http://www.mitre.org

Number of MEng Students Needed:  To Be Determined

Required Skills:  This project requires 2 broad skillsets.  The first is in the area of machine learning, which will require the ability to understand, implement in software, train, and test different techniques. Students in the Computing & Information Sciences Department will ideal for this skillset.

The second skillset needed is an understanding of signal processing, signal modulation techniques, and how to distinguish between different signals across an operating frequency band of interest.  Students from the Electrical & Computer Engineering Department will be ideal for this skillset. If signal recordings are used for the project, then then signal processing and analysis work can all be done in software.  If students have experience or are interested in working with software defined radios, then actual RF signals can be generated and received with them.

Estimated Project Time Frame:

2017-18 Academic Year, Two (2) Semesters

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For additional info, see pages 3 – 5 below.
Master of Professional Studies in Information Science

Sponsored Project Proposal Form

Please direct any questions to Kyle Harms. Email: kyle.harms@cornell.edu Phone: (314) 655-8501.

<table>
<thead>
<tr>
<th>Sponsor Name</th>
<th>The MITRE Corporation</th>
<th>Date</th>
<th>6/19/17</th>
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<tbody>
<tr>
<td>Address</td>
<td>202 Burlington Road, Bedford, MA 01730</td>
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</tr>
<tr>
<td>Contact Name</td>
<td>Matthew Kuzdeba</td>
<td>Email</td>
<td><a href="mailto:mkuzdeba@mitre.org">mkuzdeba@mitre.org</a></td>
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<td>Phone</td>
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Description of the Sponsor

MITRE is an independent, not-for-profit organization that operates research and development centers for the federal government. MITRE provides research and development, design and prototyping of new technologies, systems engineering expertise, and information technology support to government agencies, which include the Department of Defense, Department of Homeland Security, Federal Aviation Administration, Internal Revenue Service, Department of Veterans Affairs, Office of the U.S. Courts, Department of Health and Human Services, and Intelligence Agencies. Our promise to customers is that we will deliver the best solutions to their most complex technical and operational problems—with only one outcome in mind—supporting their mission. Our principal locations are in Bedford, MA, and McLean, VA, with more than 60 sites worldwide. More information about MITRE can be found on our website at: http://www.mitre.org

Please indicate which academic year and semester you would like to propose your project.

<table>
<thead>
<tr>
<th>Year</th>
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<td>Semester</td>
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Project Title

RF Signal Recognition with Machine Learning

Project Goal or Description

The goal of this project will be for students to investigate how to detect, recognize, and characterize unknown radio frequency (RF) communications signals by leveraging machine learning techniques. This is an important step towards the development of future cognitive radios that are able to autonomously establish a communications link and determine the best parameters to communicate in a congested electromagnetic spectrum, as well as providing an ability to monitor the electromagnetic spectrum and determine what other systems are operating in it. Advances in machine learning and software defined radio (SDR) have shown promise towards being able to solve this problem.

This project will ideally be a collaborative effort between Master’s Degree students in the Computing & Information Sciences Department and Electrical & Computer Engineering Department, with CIS students implementing machine learning approaches to partner with ECE students implementing the signal processing techniques for signal detection and modulation recognition.
**What activities are necessary to achieve the project goal?**

A library of RF signals with different types of modulation, bandwidths, and frequencies will either be generated or provided to the student project team. The team will be responsible for determining an approach to identify and characterize the different signals across an operating frequency band, and then implement that approach in software of their choice, such as MATLAB or Python. The team will develop and implement machine learning techniques to automatically detect and classify the signals. One set of known signals will be used for training the machine learning algorithms. A second set will then be used for testing how well the approach works on unknown signals.

Depending on the size, experience, and interests of the team, the project scope can go in a couple directions. One option is to use software defined radios (SDRs) to generate the library of RF signals, and actually send and receive RF signals as part of the data generation and collection. Another option is that MITRE can provide a recorded set of signals for the student team to use as the training set and unknown testing set.

**What outcome would determine that the project is a success? Do you expect specific deliverables?**

The expected deliverables for the project will include a final presentation, project report, and delivery of the code developed for the project.

Since this is a challenging problem, it is not expected that the student team will fully solve it and be able to accurately identify and characterize all unknown signals at the end. The goal is for the team to methodically develop and demonstrate approaches that show incremental improvements, and highlight areas worth investigating further in the future as well as lessons learned.

**What are the skills and experience required to complete the project? Please be specific and keep in mind that students will be building their skills during the duration of the project.**

This project requires 2 broad skillsets. The first is in the area of machine learning, which will require the ability to understand, implement in software, train, and test different techniques. Students in the Computing & Information Sciences Department will be ideal for this skillset.

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**The project representative must be available 30 minutes per week for status reports, the interim report, and the final presentation. As the project sponsor, are you able to make this time commitment?**

☑ Yes. Please elaborate.

On past Cornell Master's projects, we've done something like 1 hour every other week, and been available over email if needed as well. We would review and provide feedback on status and other reports/presentations as well.

Some sponsors may choose to spend additional time with the student teams, e.g. phone contacts for monthly status discussions, reviewing research results, providing midpoint project feedback, and offering input to the final deliverables in advance of its completion. As the project sponsor, are you available to participate in these or any additional activities?

☑ Yes. Please elaborate.

See above response.
The project representative needs to facilitate access to company resources as needed and approve expenses. As the project sponsor, are you able to facilitate access to such resources, should the need come up?

- Yes. Please elaborate.

If the need comes up, we've done this for other projects with Cornell in the past.

Please consider other contributions listed below. Are you willing to make these contributions? (check all that apply)

- Provide existing industry and company data as background at the beginning of the project.
- Pay one or more team members to travel to your location for initial briefing / work session / final presentation.

Please elaborate.

For the second item, in the past we've been able to provide Cornell a small amount of funding to cover the team visiting MITRE for their final presentation. We would look into that option in this case as well.

Please email your completed project proposal to Kyle Harms: kyle.harms@cornell.edu