Trends in Invigoration of Manufacturing and Engineering (TIME)

This review was written based on the Trends in Invigoration of Manufacturing and Engineering (TIME) workshops. The conference was supported by the United Engineering Foundation (UEF).

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Key Workshop Findings (summarized from talks, discussions, panels):

Automation has become easier to implement in various industries than ever before, such as the biopharmaceutical industry. The ability to automate is now built into certain equipment needed for manufacturing various products, which makes the implantation easier. Electrification makes it more feasible to implement automation and digitalization in the chemical process industry. In terms of process controls, PLC and DCS controllers are going away slowly, and we are moving towards automation controls. Machine learning has had the most advances in the last 10 years for predictive and decision making processes, which can be seen in fields such as battery manufacturing. Natural language processing is a major trend in various companies to utilize large data text to convert data into decisions. These are several of the shifts we expect to see in the future.

One issue that remains when discussing terms like Artificial Intelligence and Machine Learning in the engineering community is engineers of different disciplines have different interpretations and definitions of these technologies. AI especially can seem amorphous and can have many different definitions. Another issue engineers encounter when discussing these technologies is constantly considering if we are solving the right problem with AI. Assumptions when training algorithms are vital, and will have a large effect on outcomes. Although we expect better decision making as we can access more data, this may not necessarily be the case. Human biases in problem formation can lead to risky, problematic AI tools in manufacturing. Physical principles and physics based modelling must be used to cross-check AI behavior to avoid this problematic behavior. However, sometimes human knowledge to relate inputs and outputs is limited.

Cyber breaches are major issues for smaller companies, as less resources spent on cybersecurity will increase vulnerability to these attacks. Smaller companies can also be conduits for attacks onto larger companies, potentially putting larger companies in danger as well. Regardless of their size, various companies are links in a supply chain. Therefore, a cyber-breach can potentially affect entire industries, such as food or vaccines thereby affecting everyday life. Attacks can be financially motivated, or the motivation could be to shut off an entire system from operating. Therefore, everything from a sensor, HVAC system, to the entire financial system must be protected. Companies must not only invest in cybersecurity for these reasons, but must also work to allocate the resources in an efficient manner. Automation also takes a very long time to implement. Companies have to break up this process into measurable milestones, taking cybersecurity into account at every step.

Several other key advanced cutting edge technologies identified that may significantly impact the manufacturing field were identified:

1. Real time, hyperspectral imaging
2. Drone technology with AI, robotics with AI
3. Advances in sensor technology. Sensors have gotten smaller, “smart marble” can float around a reactor and gather measurements. This allows for real time data, which is valuable and can help to double check existing models to ensure they are correct. It also helps to address any data gaps between the process and the models
4. Computation at the edge-- Transforming raw data to reduce data set. The compact data can be sent to a model to make decisions.
5. Self-service/contactless-- remove the human from the manufacturing process, promoting remote accessibility in industry (however, this can be risky from a cybersecurity perspective).

Highlights from Several Talks:

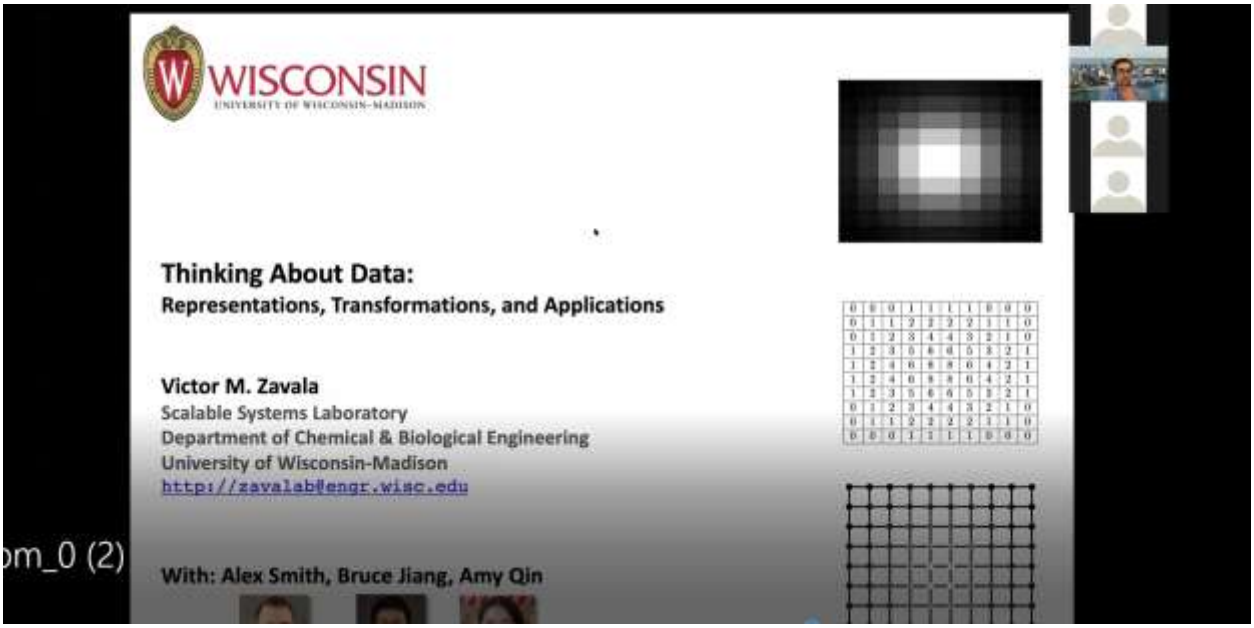
Ravi Aglave, Siemens gave a talk about AI in assessing engineering processes, designing decisions and smart controls. AI can aid in designing decision support by enhancing simulation efficiency for optimization and interpreting results, support simulation-based design, and aid in generative engineering, which relies on inputting data (including products already in use) to generate alternative solutions and validate the designs. AI is helpful in iteratively evolving a design to achieve desired properties or KPIs. AI can be used to generate performance specs of a new material to minimize the cost, which has additive manufacturing applications.

Sam Adhikari, Sysoft Corp gave a talk about reinforced learning and automation based cybersecurity for 5G aviation eco systems. Reinforced learning is a machine learning process based on training algorithms to adjust actions with a reward and punishment system. The systems work to maximize reward and minimize punishment. Robotics process automation is a process automation technologies that can be coupled with reinforced learning for various applications.

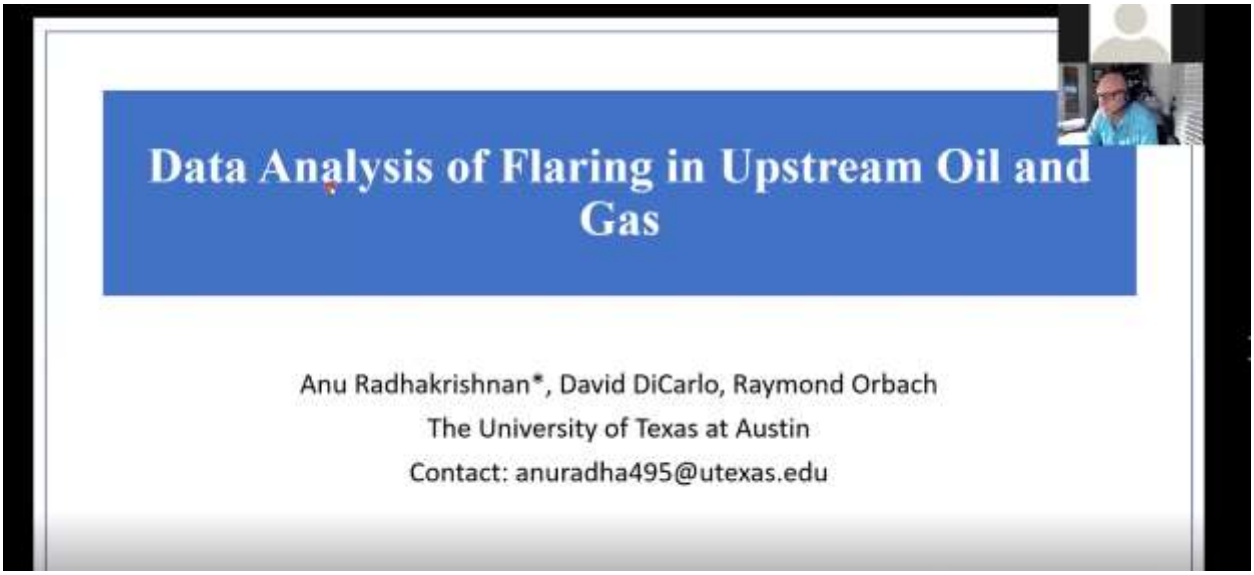
Ashwin Venkatraman, Resermine gave a talk about automating oil reservoir surveillance and management. In oil reservoir production, a water injection is made to supplement decreasing oil recoveries, and a CO2 gas injection is made for sequestration in oil fields. Physics based models can be used to make decisions regarding these injections to optimize the production process and mitigate negative environmental effects of these technologies.

Siddharth Patwardhan, University of Sheffield gave a talk regarding using machine learning applications to design bioinspired new materials. Speciality silicas are worth billions per annum, used in areas such as food additives and cosmetics. Methods to manufacture silica are unsustainable, and large scale manufacturing uneconomic. A bioinspired process can mitigate these issues,

Victor Zavala, University of Wisconsin-Madison gave a talk about analyzing data. An image can be broken down into pixels, whose intensity can be quantified, represented as a matrix, or mapped onto a manifold/function. The matrix can be represented as a node-weighed graph. Data transformation techniques that are becoming popular include convolution (applying a signal to a filter to generate new signal, and can be used for pattern matching or filtering), creating convolutional neural nets, and topological data analysis. Applications of these techniques can be environmental, such as air contamination detection.



Anuradha Radhakrishnan, University of Texas at Austin gave a talk regarding flaring in upstream oil and gas production. Flaring refers to disposing excess gas during oil production, and results in the release of methane to the atmosphere. Data from sensors on satellites can be analyzed for a top down approach to decrease emissions.



Joe Perino, LNS Research gave a talk regarding digital twins, which represent assets, processes, etc. based on data and models incorporating science and engineering for advanced analytics.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Digital Twins:
Process Plants and
Asset Intensive Industries