A Workshop on New Horizons for Next Generation Manufacturing with Robotics Learning Experience

Dr. Richard Chiou, Drexel University

Dr. Richard Chiou is Associate Professor within the Engineering Technology Department at Drexel University, Philadelphia, USA. He received his Ph.D. degree in the G.W. Woodruff School of Mechanical Engineering at Georgia Institute of Technology. His educational background is in manufacturing with an emphasis on mechatronics. In addition to his many years of industrial experience, he has taught many different engineering and technology courses at undergraduate and graduate levels. His tremendous research experience in manufacturing includes environmentally conscious manufacturing, Internet based robotics, and Web based quality. In the past years, he has been involved in sustainable manufacturing for maximizing energy and material recovery while minimizing environmental impact.

Mr. Carlos Michael Ruiz, Drexel University
Dr. Michael G. Mauk, Drexel University

Michael Mauk is Assistant Professor in Drexel University's Engineering Technology program.

Mr. M. Eric Carr, Drexel University

Mr. Eric Carr is an Instructor with Drexel University's Department of Engineering Technology. A graduate of Old Dominion University's Computer Engineering Technology program and Drexel's College of Engineering, Eric enjoys finding innovative ways to use microcontrollers and other technologies to enhance Drexel's Engineering Technology course offerings. Eric is currently pursuing a Ph.D in Computer Engineering at Drexel, and is an author of several technical papers in the field of Engineering Technology Education.

Prof. Tzu-Liang Bill Tseng, University of Texas, El Paso

Dr. Tseng is a Professor and Chair of Industrial, Manufacturing and Systems Engineering at UTEP. His research focuses on the computational intelligence, data mining, bio- informatics and advanced manufacturing. Dr. Tseng published in many refereed journals such as IEEE Transactions, IIE Transaction, Journal of Manufacturing Systems and others. He has been serving as a principle investigator of many research projects, funded by NSF, NASA, DoEd, KSEF and LMC. He is currently serving as an editor of Journal of Computer Standards & Interfaces.

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Abstract

The swift development of manufacturing within the U.S. has generated much interest in various industries. These industries include Food, Electronics, Medical, Energy, and Urban Manufacturing. Due to the traction of interest, large investments have been promoted by commercial and governmental organizations to promote innovative solutions from various disciplines to reduce costs, increase revenue, and remain a global competitor. The workshop provided insight to historical contexts of manufacturing provided by industry experts and displayed the importance of collaborative research from multidisciplinary fields of engineering. A direct correlation to diverse disciplines of engineering was given to display commercial necessity to solve complex problems with effective solutions. Such solutions to manufacturing require experimental studies to justify long term investment. The event was titled "The New Horizons for the Next Generation Manufacturing Workshop." Students were given various presentations that were followed by a Q&A session. A luncheon was followed to increase industry networking and exchange of information. The hands-on robotics and automation competition proceeded the industry session. Student disciplines included electrical, mechanical, biomedical, computer, and industrial engineering. The competition involved complex problems for robotics and automation. Several 6-axis robots were combined with various sensors and integrated with Arduino to simulate a miniature desktop manufacturing process. The workshop was beneficial to students as it supported diverse solutions to various manufacturing industries and promoted innovation for research and development.

Introduction

The manufacturing sector has produced solid gains as a result from increased interest to research and implement automated processes for products and services. Durable manufacturing, specifically automotive, displayed a large increase of 4.7% in December of 2018. Due to high demand, various areas of manufacturing have seen selective investments to increase advanced technology and improve efficiency[1-5]. The event was titled "New Horizons for Next Generation Manufacturing Workshop". The workshop addressed the trends of industrial transformation as well as the readiness of new technologies to enhance productivity and quality for next generation manufacturing. While worldwide manufacturing sits on the verge of a major transformation, new information and production technologies are rapidly offering solutions for making the control of manufacturing more innovative and efficient. It is clear that the manufacturing field of the 21st century needs unique contributions and novel approaches to solving today's complex challenges and those of the future. Common areas of concern have been the ability to modernize mid-sized factories that lack funds to advance aging technology. The digital age has provided cost effective alternatives to increase productivity and allow customization of products[6-8]. All companies need to be better positioned to integrate these new technologies into their manufacturing and business practices in order to remain competitive in the global economy. In particular, enabling technologies and research advances in future manufacturing will be discussed.

Figure 1. New horizons for next generation manufacturing workshop flyer

Figure 2. Discussion sessions during the presentations

Workshop Series

The workshop on next generation manufacturing topics was conducted by Drexel University to address the trends of industrial transformation as well as the readiness of new technologies to enhance productivity and quality for next generation manufacturing--with case studies. The workshop was organized and coordinated with the Industrial, Manufacturing, and Systems Engineering Department of the University of Texas at El Paso during the first day of June, 2018. We addressed how the US manufacturing issues on the verge of a major transformation, new information and production technologies are rapidly offering solutions that not only make the control of manufacturing more efficient, but also the process itself innovative and more cost-effective. In particular, enabling technologies and research advances in future manufacturing were discussed. The key components of emerging technologies were found in a variety of loosely-related current research areas in the workshop. As shown in Figure 2, a series of technical presentations were implemented to cultivate skills and knowledge of engineering students by exposing next generation manufacturing technologies.

Presentation #1
Opening remark: US Next Generation Manufacturing

Organizer: Richard Chiou, Ph.D., Associate Professor, Department of Engineering Technology, College of Engineering, Drexel University

Abstract: Insights from outside of the manufacturing industry will be explored in the workshop from traditional manufacturing to factory planning and utilization, quality assurance and even research and development. Indeed, industrial manufacturers can best serve their customers (and themselves) by designing tools and equipment that improve the efficiency, costs, and performance of factories and other capital projects. Whether enhancing their or their customers' plants, industrial manufacturers have an opportunity to profit from innovation strategies that build upon advanced manufacturing concepts and the potential of the advanced technology. Discussion will occur surrounding the importance of moving past simple metrics and data analytics and how the true benefits come from combining pervasive digitization with proactive modeling and simulation. Future directions for the manufacturing enterprise will be highlighted and how these same principles might be effectively applied in the industry.

Presentation #2
Title: Advances, Challenges, and Developments in Electronics Manufacturing

Abstract: The electronics industry is continuing to advance around the twin channels of design and manufacturing. As designers drive to pack more capability into products and make them smaller, faster, and more capable, so the manufacturing equipment and knowledge must devise ways to keep pace with these advances. This presentation will be covered in two stages, first there will be presentation describing the state of the art in electronics assembly manufacturing, and current best practices. This creates a base line of knowledge. Building on the first stage, the second part of the presentation will discuss current advances in manufacturing processes and equipment, specifically high speed Optical inspection and 3D Computerized Tomography for the programmable components. A look into the future will be covered.

The presenter is the senior applications engineer, business/development, XXXX. XXX is responsible for creating large circuit boards to display pictures of I95 highway's electronic billboards. Insights from outside of the manufacturing industry was explored in the workshop from traditional manufacturing to factory planning and utilization, quality assurance and even research and development. Indeed, industrial manufacturers can best serve their customers (and themselves) by designing tools and equipment that improve the efficiency, costs, and performance of factories and other capital projects. Whether enhancing their or their customers' plants, industrial manufacturers have an opportunity to profit from innovation strategies that build upon advanced manufacturing concepts and the potential of the advanced technology. Discussion occurred surrounding the importance of moving past simple metrics and data analytics and how the true benefits come from combining pervasive digitization with proactive modeling and simulation. Future directions for the manufacturing enterprise were highlighted and how these same principles might be effectively applied in the industry.

Presentation #3
Title: Selected Advanced Design Solutions for Aircraft Industry

Abstract: In presentation, the overview of selected advanced design solutions in application to aircraft industry is provided. Authors show examples of modern manufacturing processes which cut cost and time of manufacturing. It is especially important in production of complicated parts where aircraft high quality is required. This manufacturing design process is supported by industry examples.

The presenter from a Corporation spoke on the Selected Advanced Design Solutions for Aircraft Industry. He talked about a patented process and the American Manufacturing Users Group. He gave examples like how the titanium components for an aircraft was 3D printed and worth a total of 3 million dollars. He explained that titanium is 3 times lighter and 2 times stronger than steel, which makes it the perfect material for making complicated aircraft parts. He also mentioned how Boeing plans to print more than 600 parts for their space craft/taxi and their plans of testing it in 2018. The overview of selected advanced design solutions in application to aircraft industry is provided. He showed examples of modern manufacturing processes which cut cost and time of manufacturing. It is especially important in production of complicated parts where aircraft high quality is required. This manufacturing design process is supported by industry examples.

Presentation #4
Title: Crawler Inspection Robot with Machine Vision
Presenter: Bill Tseng, Ph.D., CMfgE, Professor, Department Chair, Department of Industrial, Manufacturing and Systems Engineering, The University of Texas at El Paso

Abstract: The presence of foreign objects (FO) in an aircraft can mean failure to achieve a mission's objective, loss of aircraft, or a catastrophic failure such as loss of life. Currently, Lockheed Martin inspection methods for foreign objects include a person accessing very tight areas that have the potential for FO to be present. There is a need that has been identified to remove the person from this very tight/potentially hazardous area that is being inspected and placing them behind the control center of a remote inspection system that can identify, objectively, whether or not FO is present or not. The proposed inspection system will integrate a machine vision system capable of automatically identifying and qualifying certain features and attributes with an automatically or remotely controlled vehicle that is capable of maneuvering and accessing hard to reach areas of high importance. The system's status and controls will be shown on a user interface for the person overseeing the inspection as well as a different user interface for personnel observing the inspection. Objects that have not passed the inspection criteria will be identified a record will be generated automatically in a report of the inspection. The video of the inspection will be archived for future reference.

The crawler project with a company for aircraft inspection is attempting to reliably take the human component out of inspections for aircraft. A tracked small robot that can handle driving on walls and ceilings and fit into the small spaces in aircraft frames, would be able to locate foreign objects and defects in the aircraft that we otherwise would have a very hard time detecting. Using a fan to sick the vehicle to the surface, no matter the angle gives the crawler the ability to maneuver without having a major impact on the surface it is driving on. The prototyping for the crawler involves some very advanced technologies, using a camera to allow the robot to see, and giving it the ability to decipher objects and defects from the functional interior of the plane is one of the challenges they are still trying to overcome. This project has been substantially helped out by

things such as CAD programs and rapid prototyping aids that let the project move ahead much faster. This is more important when using new materials such as polymers and carbon fiber.

Presentation #5
Title: The Evolution of Urban Manufacturing – 1970 to Present

Abstract: This presentation reviewed the state of Urban Manufacturing during the 1970's in contrast to its condition today, using Philadelphia as the model. We also looked at how the perception of manufacturing has changed, particularly from an economic development perspective and the impact that perspective had on the development of this economic sector.

The Urban Industry Initiative works with the community to entice manufacturing to stay in their respective cities. In 1970 Philly had 20% of its pop in manufacturing. The 10 square miles around Port Richmond had 340 manufacturing firms. The community's next to factories were resided by owners and workers. Over time, this comradery was broken. The Manufacturing Alliance of Philadelphia has a goal to increase the qualified workforce for the next generation of manufacturing labor. With the advent of rapid prototyping and using processes such as 3D printing, computer modeling and automated manufacturing the skills needed by workers are much more different today than in the past. The sizes of facilities has drastically reduced and many companies are making only a few very specialized products. The goal of the alliance is to get kids in middle and high school interested in these types of careers, which can help employ more people locally and grow the manufacturing in the city. There are thousands of manufacturers in the city that have trouble finding qualified employees, which makes programs in high schools and middle schools that can teach how to work on the equipment for modern manufacturing as well as how that equipment produces the products.

Presentation #6
Title: So.....What Does Engineering Have To Do With Making Food?

Abstract: The presentation provided a brief glimpse of what life is like inside a typical food plant highlighting many internal issues and challenges that are faced on a day to day basis by most food plant operators. Emphasis was placed on those areas frequently impacting the 'technical' community within the facility and their impact on the engineering and manufacturing areas. The presentation will also highlight several external issues and consumer trends facing the food industry, and those trends that could impact the engineering resources and technologies in the future. A brief summary of some of the plant technologies and their applications currently in use was also be covered. The presentation continued with a discussion of what the engineers' role can be in helping to lead and support the 'technology transition', what new skills are needed in the facility to be successful in the changing environment and conclude with a few words on career development.

Mr. Britcher was discussing engineering's relationship to food. Conveyer belts take food stuffs into freezers then directly to automated cutting stations. The freezing process has been known to shrink cakes and have caused packaging incongruences. Innovations of these machines improved this as well as other marketing concerns. The consumers are so happy with individually packaged foods that they are outsourcing the real foods. Big name companies have been outsourcing to

smaller companies to produce niche products. RTE rooms are ready to eat. Any foods coming of those lines are fully safe for consumption. The process is so hands off that the first person to lay hands on the food is the consumer. South Korea is investigating food to be a product to 3D print customized food. The diversity of engineering's relationship with the food industry is ever growing.

Presentation #7
Title: Algae for Biofuels: Aquaculture as a Production System
Presenter: Michael G. Mauk, Ph.D., Assistant Professor, Department of Engineering Technology, College of Engineering, Drexel University

Abstract: Algae are single-cell microorganisms that convert CO_2 and sunlight to biomass, which can be converted to biodiesel, commodity chemicals and feedstocks, specialty chemicals, and animal and human food. Algae can be grown naturally in stagnant ponds, but higher yields are possible in controlled culture systems. Moreover, algae culture can be combined with photovoltaic solar cells in hybrid systems that produce biomass and solar electricity to better utilize the energy in sunlight. Further, the required CO_2 can be extracted from the atmosphere to reduce greenhouse gasses. In this presentation, we discussed algae culture as an example of a microbiology production system from an engineering perspective of instrumentation and sensors, prototyping and manufacture, plastics engineering, control, optics, fluidics, energy management, and solar energy engineering.

The final presentation given by Dr. Mauk, on renewable fuels made from algae. Growing algae in conjunction with photovoltaics, which use now the majority of the light spectrum gives us the ability to combine production of two much needed forms of energy. The fact the supply of oil within the earth is limited, pushes us to find a form of fuel that is able to be produced without the fear of running out, and if we can combine that with the production of electricity which is equally important greatly reduces the space and time required to supply the population with energy. Whether it is driving or turning on the lights in home, all that energy has to come from somewhere.

Student Robotic Competition
Title: Arduino-based control of six-axis robots
Presenter: Eric Carr, MSCpE, Instructor, Department of Engineering Technology, College of Engineering, Drexel University

The hands-on portion of the workshop introduced students to the use of a six-axis robotic arm. Students learned to control the arm by specifying the correct movement angles for the six servomotors in an Arduino sketch. Sample code was provided, and students were initially led on a walkthrough of an example exercise before being turned loose to accomplish as many challenge tasks as possible during the given time interval. Challenges included tasks such as collecting objects and storing them in a bin; stacking objects, or perhaps using the robot arm to put together a simple assembly of parts. The difficulty for this portion of the workshop was adjusted with given input of prior coding experience from the registrants surveyed online. The scale for prior coding experienced was ranked from least to greatest with a given scale (1- being the lowest, 5-being the highest). 45.5% of the student registrants had prior coding experience with the majority selecting 3 from the scale. The hands-on portion of the workshop was implemented to give students an

understanding of a simplified manufacturing process with sensor fusion to simulate an automated process during distribution. Figure 3 displays the competition's 1st and 2nd place ranked teams and some of the sensors integrated with 6-axis robotics arms.

Figure 3. Hands-on robotics competition winners - simulated manufacturing process

Assessment of Workshop

The "New Horizons for Next Generation Manufacturing Workshop" was sponsored by US Department of Education. An online registration was created with a survey to determine the event's audience of interest. 65.6% of the registrants were enrolled freshmen within engineering (Figure 4).

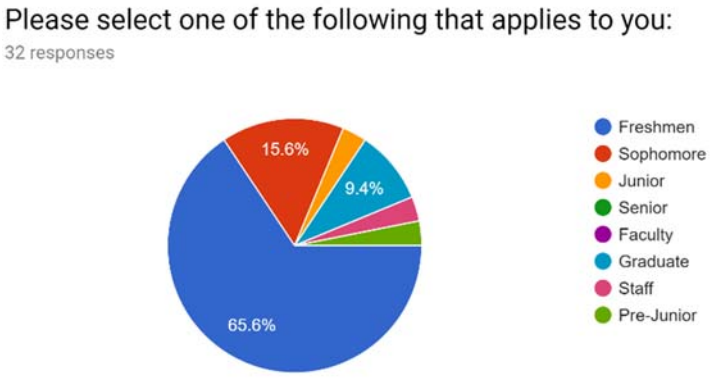

Figure 4. Registrant's academic level

According to registration surveys, nearly 68% of the registrants were interested partaking in the hands-on robotics competition of the workshop. This displayed a significant interest of students seeking to get involved with activity-based learning. The students' areas of concentration varied from mechanical, electrical, undecided, and biomedical engineering with the leading majority of 37.5% composed of mechanical engineering. The seminar session was given by various industrial partners and faculty. This enabled flexible and direct communication to understand and develop further research methods with consideration to versatility of manufacturing industries. Such productive conversations included areas of the food industry, which students seemed very enlightened to see sophisticated manufacturing processes that are still seeking innovative technologies to improve.

In order to determine the perceived level of quality of all of the presentation workshops, Table 1 presents the percentages for each evaluation item in the scale and across the different scaling levels of quality with 19 survey samples. These results allow for the examination of how program participants perceived the delivery of all the workshop sessions in general. It was clearly observed that for most of all the evaluative items, the participants overwhelmingly rated the presentations as "essential" or "helpful".

Table 1. Survey Result: Percentage of participants' responses to individual items for all workshop presentations and student robotic competition session.

Essential	Helpful	Marginal	Not Needed	Feedback Events and Material
				Objectives of the Workshop for 2018
42%	58%	0	0	Disseminate what next generation manufacturing is and its impact to the future of US
53%	47%	0	0	Address next generation manufacturing roles in industry and strategies on its integration with technologies
53%	47%	0	0	Investigate the implementation of technologies for future manufacturing based on the needs of the industry

37%	47%	16%	0	Establish a networking infrastructure with other universities and industrial partners for advanced manufacturing
58%	42%	0	0	Promote the progress of technologies as future applications in manufacturing
37%	63%	0	0	Address how technology professional development programs can achieve goals in next generation manufacturing
47%	53%	0	0	Develop strategies robotics and automation for measuring quality for next generation design and manufacturing
63%	37%	0	0	Build successful curricula and programs based on the needs of the industry
47%	42%	11%	0	Broaden participating partners from universities, industry, colleges, and communities

Responses from students were positive and encouraging as students stated the following:

> "This workshop was very interesting and informative. I learned a lot about things I had no idea existed before and I was very impressed with the creativity and technology on display in the presentations. "- Anonymous Student

> "This was much harder than I thought it was going to be at first, and by the end of the day we hardly had the arm move a block. My team experienced several hardware issues but still learned about robotics and had a good time doing it. This workshop was very interesting and informative. I learned a lot about things I had no idea existed before and I was very impressed with the creativity and technology on display in the presentations."- Anonymous Student

> "This was a very interesting competition to be part of, it helped me practice my skill in programing an Arduino. There was a robot's arm made up of several servo motors that would allow the arm to rotate in different directions. We ran into a lot of problems when trying to figure out how to smoothly move the arm, it would constantly whip back and forth. Unfortunately, its movement caused for pieces to fall off and an incorrect connection caused a wire to burn. Although we did not succeed, we were able to practice." - Anonymous Student

> "This gave me a better understanding of possible ideas that I can create with my degree. More opportunities like these in the college of engineering will allow students to have a more practical view on problems in the industry." - Anonymous Student

Conclusion

In conclusion, the workshop encouraged students and faculty to engage in productive conversation to industrial manufacturing processes. The workshop did not limit student interest to one area of manufacturing but also showed versatility to research and development improving vast areas of industry with either complex or simplified cost-effective solutions. Students became thrilled with the ability to network and give input directly to industry partners. One student was highly

influenced and took initiative to assist with undergraduate research in one of the university's laboratories for improving automated processes. The robotics competition portion of the workshop displayed the challenges of implementing an automated process and showed the sophistication of each additional manufacturing process. Overall feedback from students were positive with the workshop on new horizons for next generation Manufacturing. Suggestions focused on obtaining more time to communicate with faculty and industrial partners. This can be improved with extended scheduled breaks between presentations to allow students and presenters more time for open discussion after the response session. The event displayed the necessity of communication between education, research and industry to prepare students for a career within manufacturing.

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