Integrating Sustainability Concepts Into Robotics Engineering Education at the University of Michigan-Dearborn

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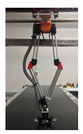
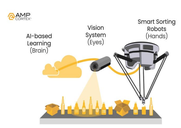
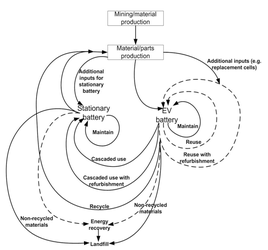
Introduction

- Sustainability concepts are very new to robotics education and research with almost no curricular initiative in the robotics engineering education domain that has addressed this very important field.





- At UM-Dearborn, we have developed ``Sustainability for Robotics'' and ``Robotics for Sustainability'' curriculum modules centered around mini-projects along the lines of **project-based learning (PBL)** philosophy.



Procedure/Methods

- Battery technology playing an integral role
- The end-of-life of the autonomous delivery system becomes an input/raw material for another company/product? Analysis of "Reuse in Electric Vehicles" and "Cascaded Use in Stationary Applications".
- A **project-based learning (PBL)** experience for considering the elements of energy-efficiency, eco-friendliness, and socio-economic sustainability in last-mile delivery mobile robotic systems
- Sprinkling themes of JEDI-focused social
- Currently implemented in the course ECE 4641-Mobile Robots at UM-Dearborn
- Students have delivered two mini-projects on the designed PBL modules.
- Be disassembled with clearly labeled materials for sourcing?
- Become an input/raw material for another company/product?
- How does closing of a company/industry impact a community/planet?
- The ideas have been pitched to all the participating faculty members at UM-Dearborn through the PBL-Palooza event at UM-Dearborn.

Inventing Green
A Toolkit for Sustainable Design

1. Supply Chain 2. Product Use 3. End-of-Life

VENTUREWELL™ idea to impact

Course	EOP Framework Outcome	Equivalent ABET LO
(Courses on Robotic Manipulators) ECE 3641 (Robotic Manipulators) ECE 543 (Kinematics, Dynamics and Control of Robots)	→ Critical thinking (Leadership) → Design (Technical) → Environmental Impact Measurement (Technical) → Materials Choice (Technical)	1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors
(Courses on Mobile Robots) ECE 4641 (Mobile Robots) ECE 544 (Mobile Robots)	→ Critical thinking (Leadership) → Design (Technical) → Environmental Impact Measurement (Technical) → Materials Choice (Technical)	4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts

Progress and Plan for Scaling Up

- **Post-pilot expansion:**
  - Branching out to other courses (even non-robotics courses, including ENG100 taught by Professor Delean Tolbert)

ENG100 taught by Professor Delean Tolbert

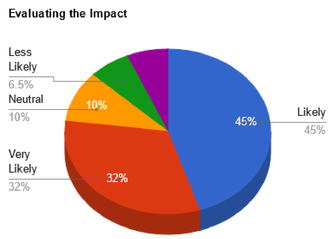
  - Full support of the College of Engineering and Computer Science (CECS): "*And throughout the college, there's a huge emphasis on project-based learning that helps students master both technical and non-technical skills.*"

  - Initiation of research efforts at the intersection of robotics engineering and sustainability (U-M Graham Sustainability Institute)

GRAHAM SUSTAINABILITY INSTITUTE UNIVERSITY OF MICHIGAN

Evaluation and Impact

- **Evaluating the Impact:**
  - A self-assessment form for the participating students with an emphasis on quantifying the likelihood of promoting the sustainability concepts/framework to the robotics/automation industries in Southeast Michigan (where most UM-Dearborn graduates start their careers in) after graduation.



References

- Inventing Green: A Toolkit for Sustainable Design. *VentureWell, 2022.*
- Collaborative robots in e-waste management. *Procedia Manufacturing*, *11*, pp.55-62.
- Onoda, H., 2020. Smart approaches to waste management for post-COVID-19 smart cities in Japan. *IET Smart Cities*, *2*(2), pp.89-94.
- Alfeo, A.L., Ferrer, E.C., Carrillo, Y.L., Grignard, A., Pastor, L.A., Sleeper, D.T., Cimino, M.G., Lepri, B., Vaglini, G., Larson, K. and Dorigo, M., 2019, May. Urban Swarms: A new approach for autonomous waste management. In *2019 International Conference on Robotics and Automation (ICRA)* (pp. 4233-4240). IEEE.

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