A3.4
Title: Changing Perceptions of Robotics in Industry: Recent Accomplishment in Safety and Injury Risk Reduction
Authors: Mojtaba Yazdani, Andrew Merryweather

Advancements in automation and robotics have created a working environment where humans and robots labor alongside each other and together on collaborative tasks. Previously, there were few human interactions with robots during routine work, and most accidents with robots occurred during maintenance, setup and programming. Recently, humans and robots do more collaborative tasks, potentially increasing the risk of injury. This presentation reviews and summarizes research topics mainly in robotics, but emphasizes potential research opportunities to accomplish safety and protect workers through collaborations with ergonomists and safety professionals.

• Collision-free motion planning: We should carefully plan for the motions of industrial robots collaborating with humans to perform tasks quickly and efficiently while avoiding collisions with human workers. Several methods such as model predictive control, convex optimization, reactive planning and active reinforcement learning are being used to do develop such algorithms.

• Force and torque control: Low-level controllers that limit the amount of force and torque exerted by the robot during physical interactions with a human worker are needed. To reduce injury risk during unwanted collision and accidents. Impedance-based controllers are the most common algorithms in this area.

 • Human intention prediction and recognition: Robots need to be able to learn, predict and recognize a human's intention to perform a task, often adapting their motion based on the human's movement. For example, a robot may want to pack a part so the human can provide the packaging, place the part inside the package, and finish the packaging process. Probabilistic modeling and learning algorithms are used in this area.

• Human motion prediction: In addition to knowledge of the worker's current location, robots need to have ability to predict human motion in future steps to avoid future collisions. Methods such as inverse optimal control and path-integral inverse reinforcement control have shown promise in this area.

 • Safety and productivity-based motion planning:

Improvements in safety and productivity in semi-automated manufacturing is a major concern. Often these are considered competing interests. Roboticists are developing new algorithms to improve both simultaneously. In these algorithms, safety parameters and productivity are modeled as constraints and objective functions respectively. Planning for the robot maximizes productivity while maintaining worker safety.

• Task allocation between human and robot: The design of a collaborative workspace involves assigning tasks to human and robot workers. These decisions are not often based on human injury potential and physical limitations, but on robot features and capabilities. Safety and ergonomics guidelines should play an important role in deciding how to allocate tasks. Novel task allocation algorithms that maximize safety and ergonomics while maintaining performance and minimizing cost need to be developed in this area.

• Safety features for robots: Several researchers are adding safety features to robots in order to reduce injury severity. Robot airbags, brakes that stop the robot in case of collision, and using soft materials in robots to reduce contact forces have been implemented on collaborative robots.

To protect human workers in this rapidly changing industrial paradigm shift, roboticists, ergonomists and safety professionals need to work together. Combining expertise to address human safety and optimize task planning for human-robot work will help change the perception of the safety of human-robot interactions in industry. These efforts are needed to accelerate the adoption of this emerging technology in our workplaces.

Session A4
Title: Workplace Violence
Moderator: Carri Casteel

A4.1
Title: Understanding Differences in the Workplace Violence Experiences of Teens and Young Adults
Authors: Brandy Brown, Doug Myers, Carri Casteel, Kimberly Rauscher

Background: Workplace violence is an important public health problem. While workers of all ages are affected, young workers under age 25 are at greater

risk. Despite this, little is known about the problem of workplace violence among this population of workers and whether the experiences of teens are different from those of young adults. The objectives of our analysis were to: 1) identify common themes in how young workers under age 25 experience workplace violence and the consequences they suffer as a result; and 2) identify differences between teens and young adults in the experiences and consequences they report.

Methods: We conducted a series of one-hour focus groups with 31 young people who had experienced any of the following forms of violence while at work: verbal abuse; threats; physical attacks; sexual harassment or assault; or bullying. Three focus groups were conducted with a total of 21 college students at West Virginia University (13) and the University of Iowa (8), and two were conducted with a total of 10 high school students in West Virginia (5) and Iowa (5). A focus group guide was used to ensure reliability and validity of the data collected across all focus groups. Sessions were audio recorded and later transcribed. Notes were also taken by several members of the study team and debriefing sessions with the study team were also conducted after each session. The transcribed recordings, focus group notes, and debriefing notes were analyzed by two separate members of the study team using independent theme analysis. The identified themes were considered by members of the study team and key issues of concern were identified.

Results: Our qualitative analysis identified the following major themes among all young workers: verbal abuse and sexual harassment common; social media used to bully and sexually harass; micro-aggressions; differential treatment by supervisors; negative impacts on work, school and relationships; negative mental health impacts; maladaptive coping strategies; tolerating or ignoring the behavior or removing oneself from the situation versus reporting (fears). Themes particular to college students included: sees workplace violence as a problem; use of power by supervisors; management focus on customer not employee during violent event; and cliques among co-workers. Themes particular to high school students were: worries about being left alone at work; bullying episodes; supervisor mistreatment; generational issues as cause; and reports to parents not supervisors.

Discussion: Working teens and young adults are often categorized and viewed as a homogeneous group of "young workers." Results from this study indicate that when it comes to workplace violence, experiences between high school students and those only a few years older are similar yet some clear differences exist that warrant further study. By understanding the differences between young workers of different ages, and therefore, stages of development, we are able to create more effective age-appropriate workplace violence prevention and response programs and training.

A4.2
Title: Factors Associated with Taxi Driver Verbal and Physical Assaults by Passengers: Results from a Taxi Driver Survey
Authors: Cammie Chaumont Menéndez, Christina Socias-Morales, Srinivas Konda, Marilyn Ridenour

Background: Workplace violence remains the leading cause of work-related fatalities among taxi drivers, a workforce that drives for a living. There is a lack of literature exploring the range of factors associated with passenger violence in an industry whose regulation varies tremendously from city to city and currently is challenged with enforcing safety measures with the advent of transportation network companies (TNCs) such as Uber and Lyft. The study objective was to explore current safety measures, work environment, business-related factors and personal factors related to verbal and physical assaults by passengers.

Methods: Licensed drivers in two metropolitan cities were invited to participate in a 30-minute survey administered by trained interviewers. Passenger violence was measured using two separate outcomes: responding yes to having been verbally assaulted, including yelled at, threatened or insulted by a passenger in the last 12 months and responding yes to having been physically assaulted, including being hit, pushed or grabbed by passenger in the last 12 months. Safety measures included safety equipment and training. Work environment included a short safety climate scale and job demands. Business-related factors are work scheduling, years driving a cab, and ownership of cab and medallion. Personal factors included gender, age, race/ethnicity, nativity and educational attainment. Passenger violence was modeled on safety measures, work environment, business-related and personal factors

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