National Institute for Occupational Safety and Health

Robotics Research and Applications for Occupational Safety and Health

Presenter: Marvin H. Cheng

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1

What is Robotics?

Robotics refers to anything involving robots which are programmable machines and able to carry out a series of actions autonomously or semi-autonomously.

Caged robots, collaborative robot systems, mobile robots, exoskeleton systems, off-road autonomous equipment, drones, future robots using advanced artificial intelligence

Robotics ≠ Automation

2

Robotics and Worker Safety and Health

Potential

- Expand dangerous work done by robots
- Robotic systems augment workers' abilities: precision and repeatability

Concerns

- Likely increase in injuries
- New types of robots will require refined and new protection strategies
- Rapid advances in technology may outpace standards setting
- Stress associated with changing workplace and potential for displacement

3

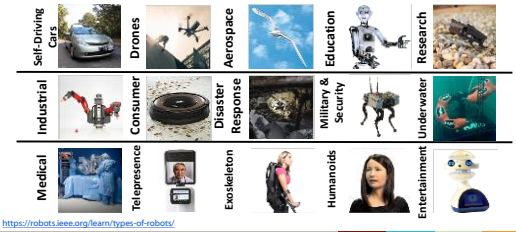
Outline

- Background
- Center for Occupational Robotics Research
- Research needs
- Burgeoning research portfolio
- Conclusions

4

Robots Nowadays (Categorized by IEEE)

It's not easy to define what robots are, and it's not easy to categorize them either. Each robot has its own unique features, and as a whole robots vary hugely in size, shape, and capabilities. Still, many robots share a variety of features.



https://robots.ieee.org/learn/types-of-robots/

5

Traditional Robots Have a Good Safety Record

- Safety record: 61 traditional robot-related deaths, 1992-2015, CFOI*
  - Identified using keywords
- < 1% of more than 190,000 workplace injury deaths during that timeframe**

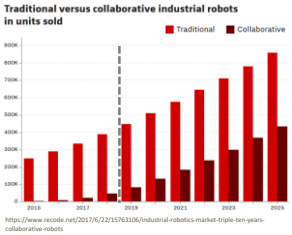
Traditional Robots: Fixed in place or caged for use in industrial automation applications

Image by © 2016 Thossaphol/Getty Images

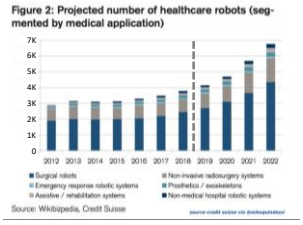
*Published analyses by NIOSH. Through a MOU with BLS, NIOSH receives Census of Fatal Occupational Injury (CFOI) research files with restricted access requirements. Views expressed herein do not necessarily reflect the views of BLS.
** Data from publicly available CFOI data.

6

Robot Sales Are Now Increasing, Including for New Types of Robots



https://www.recode.net/2017/6/22/15763106/industrial-robotics-market-triple-ten-years-collaborative-robots



7

Robotic Applications in Medicine and Healthcare

- According to a recent report by Credence Research, the global medical robotics market was valued at $7.24 billion in 2015 and is expected to grow to $20 billion by 2023.
- Top robotic applications in medicine and healthcare:
  - Telepresence
  - Surgical Assistants
  - Rehabilitation Robots
  - Medical Transportation Robots
  - Sanitation and Disinfection Robots
  - Robotic Prescription Dispensing Systems

8

Center for Occupational Robotics Research

9

Center Mission

Provide scientific leadership to guide the development and use of occupational robots that enhance worker safety, health, and well-being.

Photo by © 2014 ndoeljindoel/Getty Images

10

Center Scope

- Traditional industrial robots
- Emerging robotics technologies
  - Collaborative robots
  - Mobile robots
  - Powered exoskeletons/exosuits
  - Remotely controlled and autonomous vehicles and drones
  - Future robots using advanced artificial intelligence

11

Opportunities to Enhance Worker Safety 1

Welding ship ribs requires the worker to kneel or squat on the plate to weld, which results in stresses to the worker's back, neck, and legs. A robotic welder at a shipyard can help reduce worker musculoskeletal disorders.

Source: https://www.cdc.gov/niosh/topics/ergonomics/ergship/kneepad.html
https://www.cdc.gov/niosh/topics/ergonomics/ergship/robot.html

12

Opportunities to Enhance Worker Safety

Many lab testing tasks are monotonous, require precision processes, and possess potential health risks. Compact and easy-to-use collaborative robots offer potential to enhance worker safety

Source: https://jobs.cdc.gov/; http://blog.robotiq.com/bid/71494/ Universal-Robots-Release-their-New-Generation-of-Collaborative-Robots

13

Opportunities to Enhance Worker Safety

Transferring a patient from a bed to a wheelchair is one of the most strenuous tasks for health care workers. Collaborative robots offer potential to healthcare entities as patient transfer assist aids.

http://www.rentittoday.com/rental-blog/8576/lift-rentals-foster-patient-caregiver-safety
http://japanese.newstime.jp/?p=9071

14

Opportunities to Enhance Healthcare

Robotic devices have been used or investigated in many healthcare applications. They can assist patients to perform their rehabilitation tasks and help them to improve their mobility.

https://exoskeletonreport.com/2015/04/12-commercial-exoskeletons-in-2015/
https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-6-33

15

Strategic Plan and Robotics Research

NIOSH Strategic Plan: FYs 2019–2023

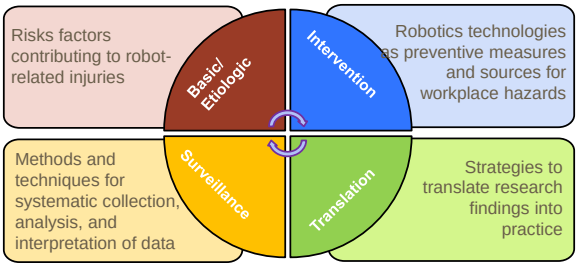
https://www.cdc.gov/niosh/about/strategicplan/

Occupational Robotics Research Needs

https://www.cdc.gov/niosh/topics/robotics/default.html

16

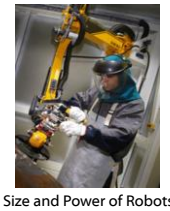
Occupational robotics research needs



17

Research: Space & Situational Awareness

Safe Distance and Path



Size and Power of Robots

Situational Awareness

https://www.assemblymag.com/ext/resources/Issues/2017/September/AIA/asb0917AIA3.jpg
http://www.imeche.org/images/default-source/articles/7a15-meulage-face-1.jpg?sfvrsn=2&size=705
http://www.dguv.de/ifa/fachinfos/kollaborierende-roboter/index-2.jsp

18

Research: Human-Robot Collision Limits


Force Tolerance


Movement Velocities


Size of Robots

https://cdn.nanalyze.com/uploads/2017/01/LocusBots.jpg
https://fm.cnbc.com/applications/cnbc.com/resources/img/editorial/2017/07/26
https://images.techhive.com/images/article/2016/08/seegrid_ge-20-min5-100676201-primary.idge.jpg

19

Research: Communication Modalities


Status and Next Action


Psychological Stresses


Communication Methods

https://www.technewsworld.com/story/76223.html
http://supplychainasia.org/next-evolution-human-robot-collaboration/
http://news.softpedia.com/news/This-Woman-Is-Actually-an-Android-Made-by-Toshiba-Video-461361.shtml

20

Research: Power, Tolerance, & Fit


False Senses of Power .


Injury Tolerance .


Vibration Exposure . Faulty Control

https://i.pinimg.com/736x/d1/1c/0c/d11c0cfaf9ecbc36284ea93ae57b84b3.jpg
https://www.asme.org/engineering-topics/articles/manufacturing-design/robotic-suits-may-transform-manufacturing
https://www.engadget.com/2016/05/13/hyundai-wearable-robot-exoskeleton/

21

Research: Traffic, Injury Risk, & Ethics

Line of sight operation risk

Impact Injury Risk

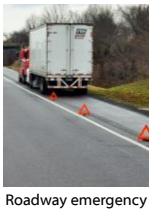
Ethics in Drone Use

https://www.vision-systems.com/articles/2017/06/nasa-s-uas-traffic-management-system-beyond-visual-line-of-sight-drone-testing.html
http://www.govtech.com/public-safety/Study-Small-Drones-Falling-from-Sky-Not-Likely-to-Cause-Head-Injury.html
https://www.xactware.com/en-us/resources/remote-sensing/news/

22

Research: Non-routine Operation & Emergency

Non-routine operation



Roadway emergency

http://cdn.newsapi.com.au/image/v1/c54afbdaab55e4875da3585cb5877ec3
https://www.overdriveonline.com/the-parking-shortage-and-north-carolinas-data-driven-enforcement/

23

Research: Taxonomy & Technology

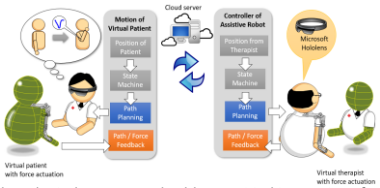
Workplace with human workers (2011)

Workplace with human and robot workers (2013)

https://www.nbcnews.com/business/autos/ford-cancels-mexican-plant-still-moving-small-car-production-n702761
http://robohub.org/42-companies-empowering-robots-and-humans-to-work-side-by-side/

24

Research: Cyber-Physical System and Remote Medical Service



- Medical cyber-physical systems are healthcare critical integration of a network of medical devices, which are progressively used in hospitals to achieve a continuous high-quality healthcare. The MCPS design faces numerous challenges, including inoperability, security/privacy, and high assurance in the system software.

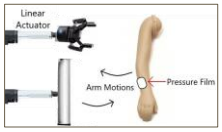
https://link.springer.com/article/10.1007/s10916-018-0921-x

25

Pilot Study: Measurement of Dynamic Force Impacts of Collaborative Robots on Humans

- Evaluate the pressure and force limits for collaborative robots on the human body during dynamic human-robot contact events
  - Human arm movement into robot
  - Human fall onto robot
- Methods: formative data collection followed by simulations
- Partner: National Institute of Standards and Technology

Contacts: Bryan Wimer



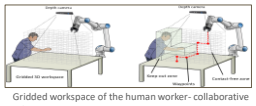
Simulated contacts between a robot and human

26

Pilot Study: Contact Avoidance between Human Workers and Collaborative Robots

- Investigate
  - motion recognition of human workers
  - strategies of path planning of a collaborative robot
  - effectiveness of a synthesized control strategy
- Methods: human subjects to identify "contact free zones"; machine learning for path planning
- Partner: West Virginia University

Contacts: Marvin Cheng, Hongwei Hsiao



Gridded workspace of the human worker- collaborative robot

27

Research: Improving Safety of Human-Robot Interaction

- Examine human behaviors while interacting with collaborative and mobile robots
- Methods: virtual simulation of robot and robot interface
  - Varying physical characteristics of robot
  - Different interface design
- Partners: North Carolina State University, Advanced Robotics for Manufacturing Institute

Contact: Hongwei Hsiao

Examples of robots with different physical characteristics

28

Research: Mining Program Research on Robotics Technologies and Automation

- Engaged for several years in supporting development of robotics technologies to improve mine worker safety and health
- In the process of prioritizing research to reflect trends towards increased automation in mining

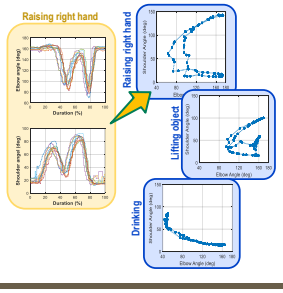
Contacts: Jeff Welsh, Todd Ruff

Prototype snake robot for mine rescue

Trends toward remotely controlled and digitized mines

29

Research: Real-Time Motion Recognition Using Artificial Intelligence



- investigate
  - Prediction of arm movements
  - Synthesis of moving trajectories for arm motions
- Methods: real-time motion identification using artificial intelligence

Contact: Marvin Cheng

Facts:
Total data sets: ~697 data sets
Training time: ~720 secs
Estimation time: ~1.2 secs

30

Future Robots

- Advanced use of artificial intelligence
- Expand to white collar and managerial jobs
- Expanded concerns about worker displacement
  - Industry reports that new jobs will be created

31

Conclusions

- **Robots in Workplace**
  - Next decade will see rapid growth and new applications of robots in workplaces
  - Robotics hold much promise for improving worker safety and health
  - Advances in occupational robotics have potential to increase risks for worker injury and will require new and refined prevention strategies
  - NIOSH and the occupational safety and health community should be proactively engaged

32

THANK YOU!

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1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

33