Welcome to the Socially Cognizant Robotics course

This is a recently established multi-disciplinary graduate course.

During the Spring semester of 2023, the meeting times will be:

- Tuesdays, 12:10pm-1:30pm
- Fridays, 12:1pm – 1:30pm

On Busch campus, SEC-117.

The course integrates the STEM disciplines of robotics (vision, manipulation, navigation, control, mechanisms) with machine learning (visual learning, language processing), cognitive modeling, behavioral research and public policy. The objective will be to allow students from different backgrounds to collaborate as part of the course assignments and projects as well as to be exposed to material from all these areas.

Primary Instructor for Spring semester 2023: Prof. Kostas Bekris (Computer Science)

Additional instructors from the following team of professors: Clint Andrews (Public Policy), Kristin Dana (ECE), Jacob Feldman (RuCCS – Psychology), Jingang Yi (Mech. Engineering), Aaron Mazzeo (Mech. Engineering), Pernille Hemmer (RuCCS – Psychology), Hal Salzman (Public Policy), Matthew Stone (Computer Science)

Assessment:
Student Presentations of Papers from the Literature (30%)
Assignments (30%)
Final Project (40%)

Tentative Syllabus: (order will likely change depending on lecturers' availability)

<u>Week 1:</u> **Introduction to the emerging domain of Socially Cognizant Robotics**
Motivation and tour of open issues in the following application domains of Socially Cognizant Robotics: (1) mobility and strength assistance, (2) food preparation, (3) trash and recycling pickup, (4) smart buildings. Brief Introduction to Socially Cognizant Robotics integrating robotics, cognitive science and social science. Considerations of impact of technology on the individual and society, ethics and unintended consequences. What does a roboticist need to know about social science? What does a social scientist need to know about robotics?

<u>Week 2:</u> **Navigation as an interdisciplinary case study**
Human navigation from a cognitive science perspective, computational algorithms for automated agent navigation (deep reinforcement learning, hierarchical RL), societal issues in self-navigating autonomous agents, human navigation and wayfinding, navigation and spatial maps, social wayfinding.

<u>Week 3:</u> **Software Tools for Robotics Development**

(simulation) CoppeliaSim using python programming or Gazebo, (message-passing interface) ROS, (visual processing) OpenCV. What can robots do robustly with existing open-source libraries for navigation, recognition, grasping and other tasks? How can robotic simulators be used for cognitive science and social science research? What are the limitations of simulated environments?

Week 4-5 **The Role of Cognitive Science in Robotics**
Decision-making by human agents; limitations of human decision-making; Bayesian decision-making. Human navigation; social wayfinding. How can cognitive scientists improve robot simulators? How can robotics be incorporated in behavioral studies in real-world scenarios?

Week 6: **Robot Vision and Perception**
3D reconstruction, recognition and semantic segmentation. Human-guided, vision-based robot skill acquisition and learn-by-example paradigms such as learning visuomotor control.

Week 7-8 **Robot Planning and Control**
navigation, kinematics, grasping, motion planning. Data-driven control to improve interactions with humans for interactive social robots. Hybrid methods that use data and experience for evaluation. How can cognitive models predict human desires during interactive processes?

Week 9 **Robot Embodiment**
grippers, manipulators, soft-robotics, exoskeletons. Soft robots and manipulators improve safety, empathy, competence in everyday tasks and social settings. Challenge and promise of human-robot exoskeletons in the workplace.

Week 10 **Language Processing**
information retrieval dialogue vs. collaboration through language. Robot-human dialog that uses physical affordances to communicate in multimodal ways (e.g., words, gestures, gaze, positioning and posture). Research on how to use contextual knowledge and behavioral models about users' goals during interaction.

Week 11 **Human interpretation of intentional behavior**, aka "mindreading."
The intentional stance; biological motion; interpreting animacy and intentionality from motion; theory of mind. How can human-style intention interpretation be incorporated into robot design?

Week 12 **Frameworks for social science research in Robotics**
collective decision making (social, economic, political), innovation processes, social dimensions of technology development and design, unintended consequences of technical change, interrelationships between technologies and people.

Week 13 **Social Science research methods for Robotics**
Quantifying how robots and society interact, ethnographic observations, sensing technology (e.g., cameras, counters), survey research and experiments.

Week 14 **Final Project Presentation**