Objective

- Develop the science and technology necessary for realizing human-robot cooperative object manipulation and transportation

Related Work

- Cooperative object lifting (HRP2 [2], Nao [3])
- Cooperative object carrying (PR2 [4], HPR2 [5])
- Current limitations:
  - Motion within obstacle-free, flat, open areas
  - Use regularly shaped objects of known dimensions and grasping points
  - Employ models of human-robot locomotion that do not explicitly consider dynamic coupling

Research Plan

- Research embodiment: Humanoid co-worker that (i) acts as a follower carrying most of the load; and (ii) communicates indirectly based on body posture and actions of the human (e.g., pointing at the object to be lifted, pulling the object towards its destination)
- State Estimation and Environment Perception: Develop active sensing and information fusion algorithms for determining the robot's pose and creating a 3D map of the area and the structures within it (e.g., location, dimensions of objects to be manipulated, stairs, doorways, etc.)
- Human-posture Estimation: Construct analytical and learned models of human motion for fusing data from IMU sensors on the person's body and visual and force/torque sensors on the robot to determine the person's current posture and predict her motion
- Grasping and Manipulation: Introduce cooperative grasp planning and manipulation algorithms based on models of human-robot grasp synergies that satisfy the dynamic constraints of locomotion and ensure safe operation
- Coordinated Locomotion: Design locomotion controllers that allow humanoid responsiveness to the human's current motion and intentions when navigating in human-centric environments
- Planning: Design humanoid motion planning algorithms for avoiding hazards and feedback strategies for responding to dynamic changes in the environment
- Safety: Develop principled approach, methodology, and algorithms for all research thrusts that predict and avoid hazardous configuration, detect potential failures, and promptly react to guarantee human safety

Motivation

- People often collaborate to lift, hold, and carry heavy objects (e.g., panels, pipes, pieces of furniture, etc.) through areas inaccessible to hand trucks or forklifts (e.g., narrow passages, stairs)
- 6M workers engaged in manually carrying, lifting freight and stock (construction sites, warehouses, etc.) Back injuries: nation’s primary workplace safety problem; 75% of them during lifting; on avg. 10 working days lost per incident [1]
- Humanoid co-workers: Possess sensors for perceiving the world, arms/hands for grasping and manipulating objects, are bipedal and can maneuver in human-centric areas w/ steps & stairs
- Complementary capabilities of humans (perception, cognition) and humanoids (strength, stamina)

Broader Impact

- Socio-economic impacts of flexible human-humanoid robot material-handling unit
  - Increase productivity and reduce cost of manufacturing, construction, and warehousing: no need for semi-permanent infrastructure; easily reconfigurable production/assembly lines
  - Reduce lifting related accidents and injuries
  - Improve quality of life of the elderly and people with disabilities (home automation)
- K-12 Education and outreach activities
  - RoboTech Fellows program for pairing K-12 students and educators with NRI researchers for enriching STEM curriculum, invigorating robotics competitions, reaching out to and attracting under represented groups
  - Public engagement through interactive demonstrations involving humanoid robots at museums, libraries, and schools

Collaborators

- Boeing, Polaris (manufacturing)
- Vecna Robotics (hospital automation)
- Innovative Design Labs (medical devices)
- Willow Garage (robotics)
- Gillette Children's Specialty (healthcare)

References