A Hands-Off Physical Therapy Assistance Robot for Cardiac Patients

Goal:
This project aims to address the nurse shortage problem through the development of socially-aware assistive robots. These robots provide motivation and support to cardiac patients who must perform regular painful breathing exercises. Thus, the robots could free nurses of selective repetitive and time-consuming patient interactions.

Cardiac Problem Domain:
Cardiac patients post-surgery need to perform regular lung exercises in order to prevent infection and facilitate recovery. The spirometry exercises must be performed ten times per hour for several days, in some cases weeks, after cardiac surgery.

Robot Control Architecture:
- **Navigation**
  The robot, Clara, avoids obstacles and navigates autonomously in a hospital room and locates the patient bed which is marked with a laser-reflective marker.
- **Patient Interaction**
  Clara interacts with the patients via its speech and video interface: pre-recorded instruction movies and a speech recognition system. The patients communicate with Clara by answering to her yes/no questions.

Experimental Evaluation:
The feasibility and effectiveness of Clara have been validated by experiments with two groups of healthy test subjects. The first round of experiments was performed in an emulated hospital room with five USC students. The second round of experiments was conducted in a patient room at the USC University Hospital with five hospital employees. The experiments showed that all of Clara's control components performed successfully. All subjects were interested in the robot-assisted spirometry exercise and enjoyed the interaction with Clara.

Nursing Shortage Problem:
The population of the United States is aging, with a predicted upcoming increase of 36 million people over 65 between the years 2000 and 2030. At the same time, the community of registered nurses is also aging. Reduced nurse staffing results in each nurse assuming additional responsibilities and an increased work volume, sometimes including mandatory overtime.

Unidirectional dynamic microphone for speech recognition
Pan-tilt-zoom camera for tracking of fluorescent color markers
LCD for playing instruction videos
Laser range finder for navigation and obstacle avoidance

Clara, the assistive interactive robot for cardiac patients

Example hospital room setup

Control flow of Clara's architecture

Clara assisting a patient with the spirometry exercise