Towards Personal Service Robots for the Elderly

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http://www.cs.cmu.edu/∼nursebot

Problem: At the turn of the millennium, the number of elderly in need of care is increasing dramatically. Today, more than 12.5% of the US population is over 65 years in age. By 2030, more than 15% of the population will be 65 and over. Current living conditions for the majority of elderly people are already alarmingly unsatisfactory, and situation will worsen in the future. According to [6], nearly 9 percent of non-institutionalized persons 70 years of age and over were unable to perform one or more activities of daily living such as bathing, dressing, using the toilet, and getting in and out of bed or chairs. The dramatic increase of the elderly population along with the explosion of costs pose extreme challenges to society.

Robotic technology, at the same time, is going through major revolutions. Sparked by a dramatic increase of computation per dollar, and by substantial decreases in the costs of major sensor technologies (e.g., cameras), we are now closer than ever to the goal of intelligent service robots than can assist people in their daily living activities. In the last few years, service robots were successfully fielded in hospitals [4], museums [1], and office buildings/department stores [3], where they perform janitorial services, deliver, educate, or entertain. Robots have also been developed for guiding blind people [5], as well as robotic aids for the elderly, but many of these are mechanical aids [7, 2] that put the cognitive load on the patient side. There has been little research to date in terms of assisting elderly people with cognitive tasks, such as remembering medication schedules. However, human-robot interaction, autonomous systems and planning have all seen major developments recently. The time is ripe to leverage the various technologies into the lives of elderly people, where the need for personal assistance is larger than in any other age group.

Approach: "Nursebot" To accommodate these needs, we are currently developing a first generation personal service robot specifically targeted at people with mild forms of dementia and other physical inabilities. The goal of this project is the development of personal robotic aids that serves four primary functions:

- **Cognitive prosthesis.** A large fraction of the elderly population suffers from varying degrees of dementia. The inability to remember can have severe consequences, such as forgetting to take medicine. People also might use a robot for lesser purposes, such as finding out what's on TV. Reminding is an important (and time-consuming) activity in a health-care professional's life.

- **Systematic Data Collection.** A key problem currently faced in the health care sector is the inability to collect data for people living in private homes. Such data include statistics on medication, daily living activities, and factors related to specific medical risks.

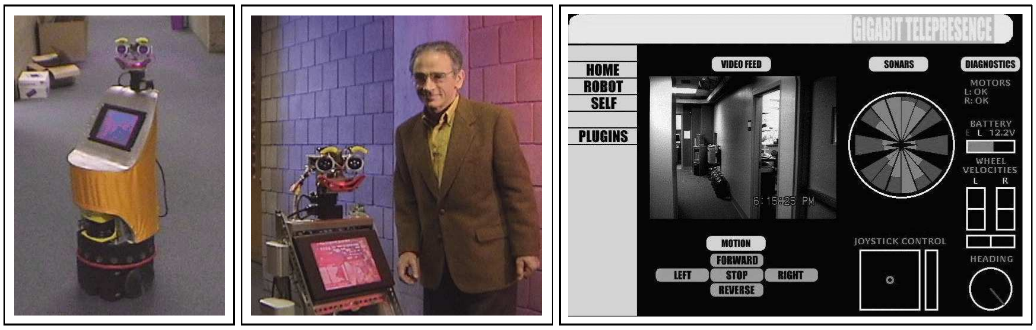
- **Remote tele-medicine.** In the US, home visits by health-care professionals are extremely rare, due to the high costs involved. The idea of robotic tele-presence is to use Internet technology to relay live video and audio from the doctor's office to the patient's living room.

- **Social interaction.** Finally, the vast majority of independently living elderly people is forced to live alone, and is deprived of social interaction. Social engagement can significantly delay the deterioration and health-related problems. While robots cannot replace humans, we seek to understand the degree at which robots can augment humans, either by directly interacting with the person, or by providing a communication interface between different people that is more usable than current alternatives.

The current prototype robot, called *Flo* (in honor of *Florence Nightingale*) is shown in Figure 1. Flo is built on top of a Nomad Scout differential drive mobile base, equipped with a SICK PLS laser range finder. There are two on-board PCs connected to the Internet via a 2mbit/sec wireless Ethernet link. A touch-sensitive color display is mounted at approximate eye height for sitting people, and Flo possesses an actuated face that can show different facial expressions. The eyes are color cameras and are motorized, which enables them to saccade when tracking a person's face. The robot is also equipped with a speaker system and a microphone.

In addition to the communication modes, the tele-presence offers control of the robot to the remote user. Using a joystick, a health care giver, friend or relative can drive the robot around the user's rooms, and also direct the robot's gaze by controlling the head configuration. The safety of the robot is guaranteed by the robot's navigation software, which limits the robot's velocity and movement so as to avoid collisions with obstacles. Figure 1 (c) shows the graphical interface, which is run inside a Web browser. The interface displays the video stream, along with the robot's sensor readings.

Dialog Management One of the major goals that has dictated the design process has been to develop a robot that allows the most natural interaction between the users and the robot. Elderly people often have difficulties interacting through unfamiliar means, such as keyboards and computer screens. It is therefore of great importance that the robot communicates in ways familiar to elderly people. To that end, spoken interaction with the robot is absolutely essential.



(a) Side view (b) Interacting (c) NGI Panel

Figure 1: (a) Side view of Flo, the robot. The robot is equipped with a touch-sensitive display, a laser range finder, an array of 16 sonar sensors, and two on-board PCs. (b) Flo interacts with a person. (c) A picture of the tele-presence interface, at the remote console.

1. User: *Flo, hello.*
2. Flo: *Hello. What can I do for you.*
3. User: *Flo, what's the weather?*
4. Flo: *Do you mean today's weather, tomorrow's weather, or the current weather?*
5. User: *Flo, the current weather.*
6. Flo: *It is currently raining with a temperature of 54 degrees.*
7. User: *Flo, thanks.*
8. User: *Flo, what's on NBC today?*
9. Flo: *NBC is currently airing the Today Show.*
10. User: *Flo, good-bye.*
11. Flo: *Good-bye.*

Table 1: Example dialogue Flo's texts are also displayed on the screen. When answering the question of what's on TV, the robot displays the program for the next four hours on its screen.

The dialog manager has a connection to a number of external sources of information, such as the World Wide Web, and thus is able to answer questions on a number of topics. For example, Flo is able to warn the user of impending bad weather, and can serve as a rudimentary TV guide. Flo also can consult an electronic datebook, reminding the user to take their medication, or that it is time to visit the doctor. Table 1 shows a "typical" dialogue between the user and the robot.

Current Project Status The first hardware prototype shown in Figure 1 has been developed and evaluated. The purpose of this prototype was to establish an "existence proof" to our project partners from the University of Pittsburgh's School of Nursing and CMU's Design Department, and to obtain their feedback on the design of robots for nursing. A secondary goal was to integrate the software described above into a running system. While the robot has not yet been tested with elderly people, feedback by our partners has identified a range of opportunities for improvement.

Future Work: Based in the initial feedback from our project partners and preliminary user studies, we have begun developing a second, improved robot platform. In particular, the next generation will be equipped with a removable basket at its front. We also are integrating a handle that provides support for people with stability problems. This handle is *not* meant as a walking aid; instead, it will be equipped with a touch sensor that will lock the robot motors as soon as a person holds onto it. Finally, we plan to add an additional rotational degree of freedom to increase the robot's maneuverability in tight spaces. This robot is currently being developed in collaboration with CMU's Design Department.

In collaboration with the School of Nursing of the University of Pittsburgh, we are currently developing a detailed "script," laying out in detail modes of interaction between nursing robots and people. Finally, we are at the verge of integrating the University of Pittsburgh's system for intelligent scheduling and planning, with the goal of developing an intelligent aid that manages support of daily living activities; in particular reminding and scheduling.

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