VirtualMe: The Telepresence Robot

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Introduction
VirtualMe (Fig. 1) is a telepresence robot designed to be used in human care and support scenarios such as medical assistance, remote education, entertainment and security. The most immediate application of this robot is likely to be the role of assistant and companion for elderly people. As our population ages there is a growing need for assistive technology that would allow people to stay independent for as long as possible. This robot is designed to be an effective and affordable example of such a technology.

Design
There are several feature that are incorporated into the design of this robot that make it useful for a hospital or nursing facility environment.

- **Robot’s Head**
  - PointGrey Bumblebee\textsuperscript{4} stereo camera (Fig.2a) 3D environment reconstruction, obstacle avoidance
  - Tablet computer
  - Teleconferencing, GUI
  - Tilt Unit (Fig.2b) Adjustable viewing angle for both stereo camera and tablet. The mount was redesigned specifically to accommodate the installation of the Bumblebee camera

- **Omnı-Camera**
  - An “omni-camera” (Fig. 3) in the base of the robot looks directly up into a spherical dome to allow for 360 degree images of the surroundings.

- **Moving Platform (Fig. 4)**
  - Three wheel base with rollers on wheels’ edges
  - Moves in any direction, turns on the spot
  - Brushless motors, belt drive
  - Quiet operation more suitable for hospital and nursing home environments

Capabilities
Currently the robot is in the development stage, but work is being done in several areas to give the robot the ability to avoid obstacles and navigate in crowded environments while remaining aware of its location.

- The environment representation:
  - In development, initial assumptions only on the maximum size of the environment. Dynamically updatable, relies on robust obstacle detection

- Obstacle detection
  - Bumblebee \textsuperscript{4} stereo camera provides depth estimation that is used to reconstruct 3D scene (Fig.5a). A watershed segmentation based approach is employed to improve the quality of the reconstruction [1]. False positives are removed as well as a depth estimation for points with unknown disparity is provided (Figure 5b).

- Detection and recognition of humans (Fig.6)
  - In development, indoor environments, detection of humans in different poses, orientations by detection of individual body parts, [\textsuperscript{5}]\textsuperscript{6}\textsuperscript{7].
  - 1. Image segmentation: stereo segmentation, region based approach with motion or textured regions.
  - 2. Classification of detected regions based on individual part-models which characterize human limbs.
  - 3. Human body modeling to integrate detected parts to estimate the pose of a detected human body.
  - Face recognition techniques could also be applied to allow the robot to differentiate individual people.

- Detection of stairs
  - An important part of the visual analysis is identifying stairs, especially stairs that lead downward. Extra effort is going to be made to find a solution for this problem.

Challenges

- **Telemetry**
  - Poor estimation of traveled distances due to inherent limitations of the moving platform (wheels slipping on the floor). Currently, there are a few approaches being considered to deal with this limitation: one is the installation of tracking sensors and the other is correction of the robot’s position based on tracked environment features [2]. It may be most effective to use a combination of both [3].

- **The quality and the position of the omni-camera**
  - Approximately 23.5\% of the image is obstructed by the body of the robot (Fig.7).

Reference


Figure 1. VirtualMe robot. More detailed views can be seen of the head in Figure 2, the omni-camera system in Figure 3 and the omni directional wheel base in Figure 4.

Figure 2. a. Robot head with mounted Bumblebee stereo camera and Android tablet b. Tilt mechanism

Figure 3. Omni-camera provides a 360 degree view of the environment.

Figure 4. Robot’s omni-wheel base and control system enables it to smoothly move in any direction including concurrent rotation without requiring a preceding rotation - ideal for navigating tight spaces.

Figure 5. a. Initial obstacle detection (red: obstacles, yellow: unknown) b. Detected obstacles after watershed segmentation

Figure 6. Diagram for human recognition module

Figure 7. Raw image from the omni-camera system

Figure 8: Unwrapped image from the omni-camera system

Conclusion

Although at the moment the robot does not perform all the tasks necessary to successfully operate in a real world environment the work is well under way to build a robust and reliable system.

Acknowledgments

Financial support was provided in part by NSERC, Canada Research Chairs Program and CrossWing Inc.