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A robotic sculpture speaking to people

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I. Abstract

This video shows the interactive robotic sculpture conceived and realized by the artist Albano Guatti. The robotic part was totally developed by people at the IAS-lab and at IT+Robotics according to Guatti's concept. This work is the result of the meeting of robotics and art. The video shows that the robot is able to locate people in the environment, to navigate toward them avoiding the obstacles and to approach them as a polite waiter will do. In fact, the sculpture represents a waiter and a waitress (actually their suits, the statue do not have a body, they represent empty suits). The waiters chat among them (by play different pre-recorded voice files) while wandering in the environment. Once the robot locates a person and get close to her, it asks the customer one out of different pre-recorded questions. The more likely is: Would you like a drink?, that is the title of the sculpture.

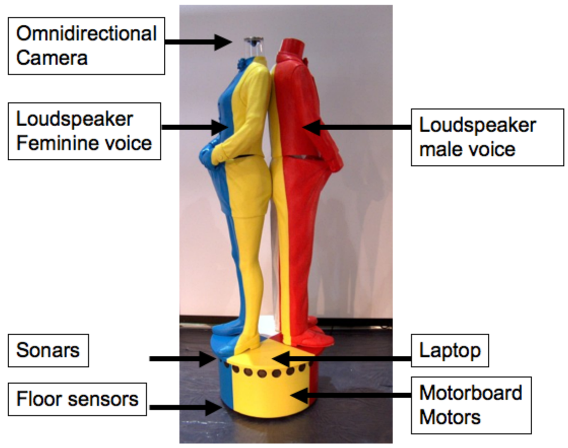

Fig. 1. The interactive robotic sculpture by Albano Guatti

II. Introduction

Back in 1981, Albano Guatti realized a radio controlled moving sculpture (an oversize skirt) that was taking pictures of the public. In this work, technology enabled to go further and to realize a totally autonomous sculpture. The external shape and appearance of the sculpture was already determined by Guatti and has been imposed as a project specification. This forced to design a robot embedded in the sculpture and to look for technical solutions coherent with the artistic theme. Therefore, from the very beginning strong constraints were posed on the possible robot mechanical structure and sensors. Together with the external aspect, other requirements were posed on the robot behaviours. For instance, the robot should not produce repetitive movements, it should be able to go out of stalemate situations, it should present fluid movements and, as far as possible, similar to human movements.The final implementation meets the requirements. The robot is autonomous and is able to navigate in an unknown and unstructured environment. Moreover it is possible to bound the working space of the robot, simply by creating a strong chromatic discontinuity on the floor (e.g., with a stripe of Dutch tape). The result is clearly shown in the videos.

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III. Robot description

A picture of the robot is reproduced in Fig. 1. The fundamental ability of this robot is the capability to detect people in a unstructured environment and to reach for them, avoiding obstacles, while staying within the bounds of its working space. To implement these functionalities three different sensors have been used, each one devoted to a specific task: (i) an omnidirectional camera; (ii)a ring of sonars; (iii) a set of floor sensors.

The robots main sensor is an omnidirectional camera (well integrated with the artistic appearance of the statue). The omnidirectional camera is used to detect the people in the environment. The omnidirectional visual perception is coupled to an omnidirectional range sensor realized with a ring of Polaroid sonar sensors. The sonars are used to detect obstacles in the environment, to avoid them and to calculate the distance of the people to be approached. A last sensor is a set of simple photoresistor circuits which can detect light reflectivity discontinuity on the floor. This can be used to bound the working space of the robot by using a carpet of a different color or by putting stripes of Dutch tape on the floor to bound the working area. The hardware and software design was driven by the experience maturated in our laboratory in designing and programming robots for the Middle-Size RoboCup Competitions.

A. *Omnidirectional camera*

The omnidirectional camera is located on the neck of the waitress statue. The omnidirectional camera was chosen with respect to classical perspective cameras in order to be

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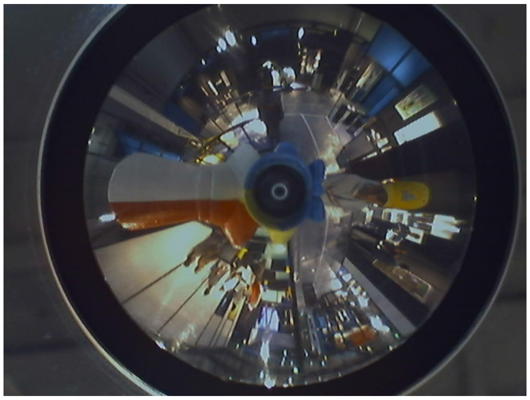

Fig. 2. An omnidirectional image grabbed during the ITC fair SMAU 2005 in Milan, Italy

able to detect the people even when they are behind the robot. In fact, the camera grabs images of the environment surrounding the robot with a 360 field of view, as shown in Fig. 2 This complete perception of the environment avoids the robot to perform rotations to look around, that would inevitably results in an unnatural motion for the robot. The omnidirectional camera is composed of a Logitech webcam (conceiled in the chest of the waitress) pointed at an hyperbolical omnidirectional mirror especially designed by the IAS-Lab [2].

The detection software is based on two filters: a motion detection filter based on the background subtraction algorithm and a skin detection filter, based on a new skin detection filter (inspired by [3]). Detection of human skin in an arbitrary image is generally hard. Most color-based skin detection algorithms are based on a static color model of the skin. However, a static model cannot cope with the huge variability of scenes, illuminants and skin types. An interacting robot has to find people in different rooms without any a priori knowledge about the environment nor about the lighting. The newly developed color-based algorithm is called *V+R filter*. The V filter is a dynamic filter based on the definition of a 2D region of a color space (that we called V region). V region depends on the statistics of first and second order of the pixel of the image and contains all skin pixels.The R filter is a static filter working in the RGB color space and has been designed to remove regions of the color space that the V filter might has selected and that with high probability not belong to the skin locus (e.g., pixels belonging to tonalities like dark gray, strong yellow, deep blue, etc). Our algorithm was designed to correctly recognizes skin pixels without exploiting any information on the camera. Once a person is detected a tracking software module is activated.

B. Sonars

The sonars are 24 Polaroid 6500 serie located around the platform of the robot. The sonars are taken from a Pioneer2 robot by Activemedia. Due to the low reliability of Polaroid sonars over long distances, we chose to limit the measurement range to 2 meters. A measure of distance reporting more that two meters was considered as free space. The sonars data are processed using a modified VHF (Vector Field Histogram) [1] to be robust to the intrinsic noise of these sensors. All the readings of the sonars are organized in a probabilistic occupancy grid, of dimensions 4×4 m relative to the robot.

C. Floor sensors

The floor sensors are used to recognize the trespass in the forbidden zone. These sensors are situated under the platform, they are four. They are designed and realized by the IAS-Lab for this application. They are simply made by a high brightness led and by a photoresistor. They are arranged in such a way that the only light incident on the photoresistor is the one generated by the led and reflected by the floor. By measuring the voltage across the photoresistor one can measure the light incident on the photoresistor and hence can have a measure of the reflectivity of the floor. The measurements of the reflectivity are stored in a FIFO queue. If there are four consecutive measures over a certain threshold, a discontinuity is detected. Therefore, the robot can be bounded to work on regions of constant reflectivity (i.e. a certain kind of floor, a carpet, ecc.). The four floor sensors are connected to the analog inputs of the Pioneer2 board.

IV. Conclusion and Acknowledgments

This paper presented the description of a autonomous robot for realizing an interactive sculpture. The sculpture was presented at a private party at Golinellis House in Venice at the opening of the 2005 Biennale of Art. The robot run for two days greatings the visitors in the entrance of the palace. After this, the robot run for five days at SMAU 2005 (the biggest Information Technology fair in Italy) moving around among hundreds of people. At the MART (Museum of Modern Art, Rovereto (TN) Italy the robot successfully run for two days in the cafeteria and in the museum hall.

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