HUMAN-MACHINE INTERFACE TO CONTROL A ROBOT WITH THE NINTENDO WII REMOTE

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Abstract: This paper intends to demonstrate the development of and easy-to-use local human-machine interface that would allow any user to control all kinds of service robots intuitively. This interface is based on the Nintedo Wii remote controller and consists of three operating modes: a steering wheel, an infra-red monitor and a movement identifier. These modes were tested on a cleaning robot and they led to very satisfactory results, proving that the Wiimote is an inexpensive and interesting way of making this kind of interfaces.

1 INTRODUCTION

With the increasing use of robotic systems in our society the human-robots working partnerships will become more common, which leads to the need of finding easy and intuitive means of communication to make them as efficient as possible. The implementation of these means of communication on a Local Human-Machine Interface (LHMI) (O. Mayora-Ibarra, 2003), (Perzanowski *et al.*, 2001) represents a great advantage since simple commands can be given in a very simple and inexpensive way.

The objective of this paper is to present the analysis and implementation of a LHMI based on the Nintendo Wii's remote controller, "Wiimote" to control a cleaning robot (Sousa, A. 2006) as a test platform (more information at the web site: http://en.wikipedia.org/wiki/Wii_Remote). The CleanRob architecture was modified in order to receive orders via the Wiimote. Several modes were made available: steering wheel, "follow the leader" and "movement identifier". The controllers used by these working modes are based on intelligent control techniques, like fuzzy control (D. Driankov, 1996), (Jenson, J., 2005) and case based reasoning (Aamodt, A. and Plaza, E, 1994).

The structure of this paper is as follows: section 2 presents the Wiimote's internals; section 3 explains the experimental setup; results are presented in section 4 and the conclusions are presented in section 5.

2 WIIMOTE PRESENTATION

The relevant Wiimote's features are:

- Tracks 4 Infra Red (IR) dots over 1024x768 pixels (43.8º x 33.5º)
- Blue Tooth communications
- 3D accelerometer +/-5G (8 bit ADC)

Interfacing with the device is possible via community developed interface libraries (example: libwiimote).

3 DEVELOPMENT OF THE LHMI

3.1 Steering Wheel

This operating mode is like a wireless steering wheel of an automobile (including go forward and go back

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commands). The control is done by tilting the Wiimote forward or backwards and/or leftward or rightwards to change linear velocity (υ) and angular velocity (ω) of the robot.

It is possible to determine how the remote is tilted by sensing the gravitational force. Starting position is measured and differences from that time on are measured (figure 2.a). When the remote is tilted forward or backwards the gravitational acceleration is measurable over x and y axis (shown figure 2.b). A leftward or rightwards tilt is represented in figure 2.c. The y and z axis accelerations are used to distinguish situations.

Figure 1: Wiimote Steering Wheel.

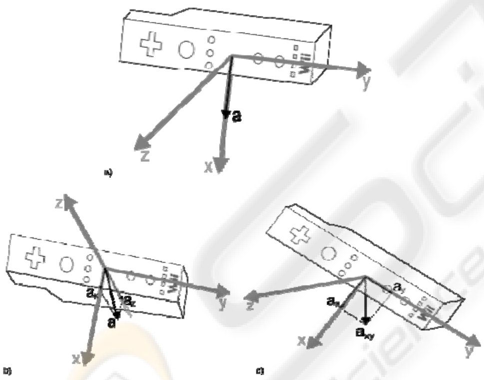

Figure 2: Gravitational vector: a) center position; b) tilt forward; c) tilted leftward.

To control operations in this mode, a PD fuzzy logic controller (based on the Mamdani architecture) was implemented. This approach is interesting due to the non-linearity associated with this movement classification. The x, y and z values are the acceleration on the respective axis. The rule base of such controllers are defined by if-then rules that uses triangular definitions for P=Positive, Z=Zero or N=Negative sets on the v and ω variables for each axis x,y,z.

3.2 Infra-Red Monitor

In this mode the Wiimote is attached to the robot and its infra-red receiver is used to detect two infra-red sources and measure their position. In order to do this it is necessary to know the distance between the two IR LEDs (d) and the flat angle on the xz plane of the remote's IR receiver (φ=43.8º).

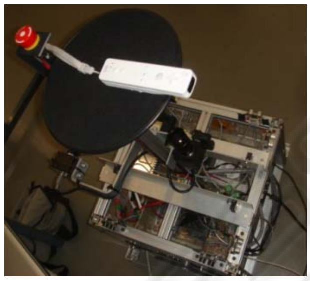

Figure 3: Wiimote attached to the robot's body.

Through the relation between the distances d, in centimeters, and the measured distance between the two IR sources, in pixels, it is possible to calculate r_2. By knowing the relation between the horizontal resolution of the image received by this sensor, 1024, and the angle associated with it, φ, it is possible to determine θ through its relations with r_2. With these two variables it's easy to calculate the distance r_1:

$$\tan\theta = \frac{r_2}{r_1} \qquad (1)$$

This operating mode can also be used to send information to the self-location algorithm since it can measure distance to walls marked with IR light sources or to IR beacons, thus improving that algorithm quality.

The main usage of these ideas is to implement a follow-the-leader mode. In this mode the IR sources are mobile and the distances r_1 and r_2, measured by the Wiimote's IR receiver, are used to calculate the velocities υ and ω, in order to keep it, and the robot in which he is attached, at a fixed distance and orientation relatively to the sources. This is done using the fuzzy controller from the fuzzy steering wheel mode. The mobile IR source is composed of two IR led's (ref. HIRL5020) connected to a 7,2V source composed of six AA batteries. In average, the batteries last 8h on continuous work.

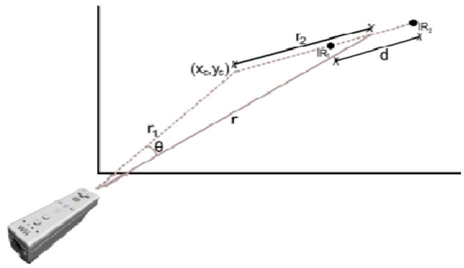

Figure 4: Schematic of the Infra-Red Monitor's variables.

3.3 Movement Identifier

In the Movement Identifier mode, the tridimensional accelerometer is used to read and save the accelerations on each axis. Movements are classified as one out of 13 pre defined situations. The predefined movements are: single stroke linear - left, right, up, down, front and back; repetitive left and right, up and down and front and back; circular movements and square shapes on the xz plane (clock and counter clockwise).

Figure 5: Controlling the CleanRob with movements.

The acceleration's graphic of a linear movement over an axis will be similar to a one-period sine wave. Detection is made by detecting maximum and minimums.

The analysis of the other movements is more complex but can be simplified if they are considered as successive and simultaneous linear movements over one or more axis.

The control method used to put this theory into practice was Case Based Reasoning (CBR) based on the model presented in (Aamodt, A. and Plaza, E, 1994). The attributes considered on each case were the following:

- Max + Min count and peak values
- Positive and Negative amplitude (max peak – min peak) centered on the average of the signal
- Time difference between peaks
- Peak sequence over time (several axis)
- Peaks of projected accelerations over XY plane and angle from acceleration vector to XY plane

This mode will allow for detection of higher level control actions.

4 RESULTS

The Steering Wheel allowed the user an easy way to control the robot's movement, although it was hard to stop it due to the constant movement, voluntary or involuntary, of the user's hands. To make stopping the robot an easier task it was created a threshold around the υ and ω zero values. To ensure that the control is not triggered involuntarily, its start and stop is done by pressing the Wiimote's A button.

The Infra-Red Monitor isn't capable of detecting IR light sources closer than 20cm from the Wiimote. The results of the measurements error module are presented in the figure 6. Notice this module is never greater than 3cm but as a tendency to increase as the distance between the IR sources and the receiver increases.

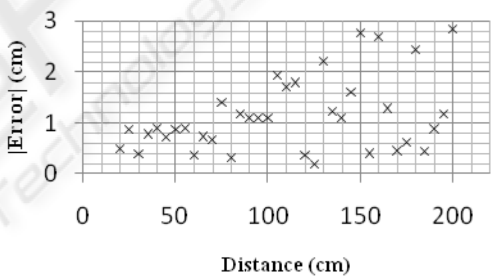

Figure 6: Infra-Red Monitor measurement error.

To test the movement identification algorithm it was necessary to compile the case base with examples of all the thirteen movements that we want to identify. In order to maximize the test of this algorithm, the movements sent into the case base were from only one person. Since how a movement is done varies from person to person, which will result in different acceleration vectors thus leading to different values of the considered attributes, by having only movements done by one person in the case base it will be possible to analyze if the attributes used in the CBR algorithm allow the consistent identification of different movements, even if there aren't any movements in the case base that were done that way.

The commands were thoroughly explained but no teaching of the testers was done and most of the testers were holding a Wiimote for the first time. The results shown in the figure 7 prove that the CBR algorithm and the attributes mentioned before can be used to correctly identify movements made by people whose movements are not listed in the case base. The proposed algorithm can distinguish the movement's orientation and can distinguish squares from circles and in which direction they were done.

After this analysis, it was noted that most incorrect identifications where due to bad input data. It was mentioned that a linear movement over an axis resembles a one-period sine wave and that information was used in the development of the CBR identifier, but if the data received isn't minimally similar to that sine wave, if it resembles a slope for instance, the movement's attributes will make the system answer incorrectly. This can be avoided if the user starts and ends the movement with the Wiimote stopped. Another cause of bad data is the speed at which the movement is done. Low velocities will result in lower accelerations that, when combined with the Wiimote's accelerometer low signal-to-noise ratio (SNR), will result in bad attributes that will make the system answer incorrectly.

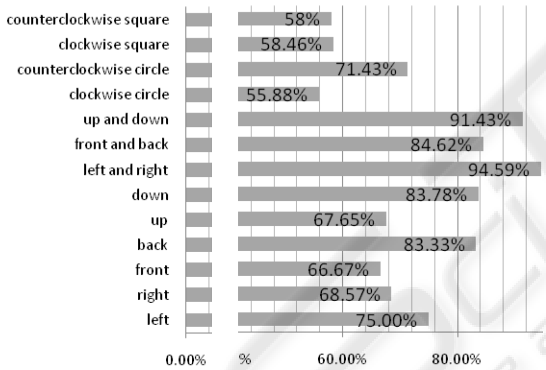

Figure 7: Correct identification percentage of linear movements by the CBR algorithm.

5 CONCLUSIONS

An implementation of a local human-robot interface based on the Nintedo Wii's remote controller was presented. Due to the Wiimote features, it is easy to use and inexpensive.

Three working modes were developed:

- The steering wheel allowed the user to set references for v and ω in order to remote control the robot in an intuitive way
- The "Follow the Leader" mode that uses distance and angle to the "leader" and is interesting to lead the robot to distant locations quickly teaming up with the leader
- The "Movement Identifier" is an interface usable in future for general commands.

The first two methods use a fuzzy controller. The movement identifier uses Case Based Reasoning.

User tests hint that system usability is easy.

In the future, new working modes might be added to the interface as well as new movements. Another possibility is to allow for multiple Wiimotes. It will also be very interesting to use the Wiimote's speaker to feedback perceived commands to the user.

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REFERENCES

O. Mayora-Ibarra 2003. From HCI to HRI - Usability Inspection in "Multimodal Human-Robotics Interactions", *Proceedings of the 2003 IEEE International Workshop on Robot and Human Interactive Communication*.

Perzanowski, D.; Schultz, A.C.; Adams, W.; Marsh, E.; Bugajska, M. 2001. Building a Multimodal Human-Robot Interface, in *Intelligent Systems,IEEE*, vol. 16, Issue 1, Jan-Feb 2001 pp. 16 – 21.

Sousa, A. 2006 - CleanRob project official website. Available at http://paginas.fe.up.pt/~cleanrob.

D. Driankov, 1996 *An Introduction to Fuzzy Control – Second Edition*, Berlin, Springer, 1996, chapters 2,3 and 4.

Jenson, J., 2005. Design of Fuzzy Controllers in *European Network for Fuzzy Logic and Uncertainty Modeling in Information Technology*, http://www.iau.dtu.dk/~jj/pubs/design.pdf

Aamodt, A. and Plaza, E, 1994. Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches in *Artificial Intelligence Communications* 7, no. 1, 1994, pp. 39-52