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Human-Robotics Interface for the Interaction with Cognitive and Emotional Human Domains

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Abstract— **For a human-robot interface it is important to have a good model of how the human subject operates. However, since such a model is difficult to obtain, then the robotics interface must observe accurately the subject's behaviour when interacting with him. We present here a new human-robot interface for active interaction with the *cognitive* and *emotional* human domains. Since eye movements convey a lot of information about one subject's cognitive and emotive status, we have designed a new human-robot interface which uses a video-based Eye-Tracker (ET) to observe the subject's line of gaze. Since we are also interested in using our interface for studying and treating depression, our interface can send stimulating inputs to the subject using both a Transcranial Magnetic Stimulator (TMS) and a visual stimulus. The latter elicits the subject's emotions and consists of a set of pictures of facial expressions, which have been shown according to a novel visualization protocol, called Memory-Guided Filtering (MGF). Its effectiveness has been verified by means of many experimental results. We also present the application of our human-robot interface for preliminary studies concerning new cognitive rehabilitation strategies in depression.**

I. INTRODUCTION

The increasing interest toward research in Human-Robot Interaction (HRI), led to the development of a great number of robots of different types (humanoid robots [1], pets [3], medical tools, etc.) in many application areas (entertainment [2], elderly assistance and health care [21], rescue robotics [15], etc.). In the last few years, we have also witnessed a growing interest towards robots that could interact more and more with humans, e.g., for the rehabilitation of *sensorimotor functions*. In order to pursue this goal, the robot must be designed to have some degrees of autonomy to monitor the human and to plan rehabilitation actions to correct the dysfunctional human behaviour [12].

Beyond sensorimotor system, the research on human-robotics interaction interfaces is extending to other fundamental aspects of the human being: the *cognitive* and the *emotion* systems. These two systems are deeply intertwined and they have been recently studied for the design of autonomous robots that must operate in conjunction with people [3]. In order to interact with humans the robot device must have a good model for how the other operates. However, a conceptual model could not be the most appropriate solution when dealing with the emotion system, which is responsible for evaluating and judging events (e.g., good or bad, desirable or undesirable, happiness or sadness, etc.). Then, the robotic device must *observe* accurately the human behaviour and then decide its actions.

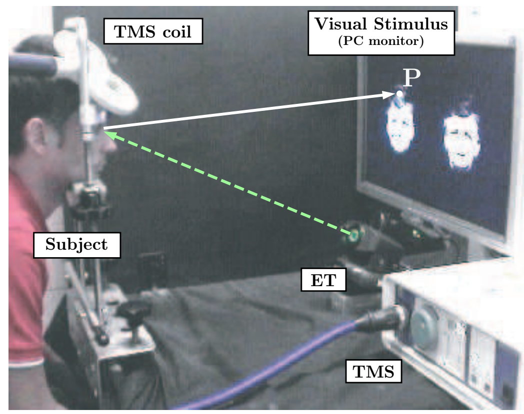

Fig. 1. Human-Robotics Interaction for cognitive and emotional study: software and hardware architecture.

We present here a new human-robotics interface for active interaction with the cognitive and emotional human domains, through a *measurement* system and a *stimulating input* system.

The measurement of the subject's behaviour is provided by a video-based Eye-Tracker (**ET**) (see Fig. 1) that can track the pupil and compute the subject's line of gaze: the eye movements convey a lot of information about one subject's cognitive and emotive status.

Stimulating inputs are given by both a Visual Stimulus and a magnetic stimulus, generated by the Transcranial Magnetic Stimulator (**TMS**) toward some subject's brain areas, through the TMS coil. We use TMS since we are here particularly interested in the applicability of our interface in the study and treatment of depression. In fact, it has been shown that the magnetic field pulses generated by the TMS coil can painlessly and transiently change the mood of depressed patients [17] and change the subjective rate of happiness or sadness [16]. Moreover, the coil position could be efficiently controlled towards specific brain areas by a robotic manipulator to which the TMS coil is fixed. In this way, the HRI will be completely automatized.

The visual stimulus, which appears on a PC monitor, has

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