Ameliorating Patient-Caregiver Stigma in Early-Stage Parkinson's Disease using Robot co-Mediators

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Abstract. Facial masking in early stage Parkinson's disease leads to a well-documented deterioration (stigmatization) in the patient-caregiver relationship. This research described in this paper is concerned with preserving dignity in that bond where otherwise it might be lost, through the use of a robot co-mediator that will be capable of monitoring the human-human relationship for lack of congruence in the perceived emotional states of the parties concerned. This paper describes the component architectural modules that are being used in support of this 5-year effort, including an ethical architecture developed earlier for the military and previous research on affective companion robots for Sony and Samsung that are able to express affective state through kinesics and proxemics.

1 INTRODUCTION

Parkinson's disease affects seven million people worldwide [1] (Fig. 1). An unfortunate side effect of the illness, due to the occurrence of facial masking [2,3] in the patient, is a deterioration (stigmatization) in the relationship between the caregiver and the client [4,5] whether this occurs in a clinical setting or at home. The net effect is a loss of dignity with respect to the client due to their inability to adequately communicate their internal affective state to the individual in charge of the person maintaining their care. Although spoken language (with some loss of prosody) still is available, most of the nonverbal subconscious cues associated with the client's emotional state are lost. This ultimately affects the quality of care given the patient with repercussions in both economic and human rights considerations.

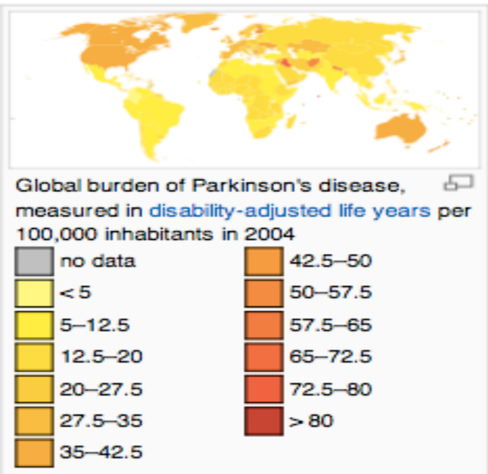

Figure 1: Global Distribution of Parkinson's Disease [1]

In a new 5-year National Science Foundation National Robotics Initiative Grant, the Georgia Institute of Technology and Tufts University[1] are exploring ways to prevent a decline in these otherwise stigmatized human-human relationships through the introduction of a robot co-mediator. The goal is to enable this robot to provide subtle nonverbal emotional cues that are otherwise unavailable from the patient, in an unobtrusive manner using kinesics and proxemics. Our previous research with Sony's QRIO robot in this area [6,7] provides the basis for an implementation in a small humanoid robot using at a minimum an Aldebaran Nao and eventually a Robokind R25 humanoid platform. We anticipate investigating other robotic morphologies as well.

We draw on our earlier computational models of moral emotions [8], initially deployed in research for modelling guilt in autonomous robots [9]. This research now expands the available affective repertoire to capture empathy levels for the caregiver while simultaneously modelling shame and embarrassment in the client. The goal is not to "fix" the relationship between the two, but rather to achieve congruence between the caregiver and patient through mediation, so that each human has a true representation of what the other is experiencing, This lack of congruence is symptomatic of the resulting stigma. While there has been some significant research to date in developing mechanisms to deploy "empathy" to a robot (e.g., [10]), it remains a largely unsolved problem. Here instead we are trying to develop effective theory of mind models (or partner modelling [11,12,13]) that capture and represent the levels of the associated human's moral emotions so that the robot can, in a homeostatic manner, then drive them back to acceptable levels if either empathy, as observed in the caregiver, is suffering from a shortfall, or to provide appropriate feedback to the caregiver should shame or embarrassment in the client reach unacceptable levels.

From a systems level to ensure these requirements are met, we are leveraging our previous research on ethical architectures, specifically the ethical adaptor and the ethical governor [12,14], to provide the computational representations and algorithms that ensure these ethical boundaries are suitably enforced. Sensing information will be derived from physiological sensors (e.g., galvanic skin response, FNARS, blood pressure, heart rate, etc.) and direct signalling through a user-manipulated paddle. Parsing of the spoken language of the client, where feasible, will also be

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evaluated, but this time with believability attached to it, which unfortunately can be lacking in the caregiver under these circumstances.

This paper is organized as follows, focusing on the supporting technology that this new research builds upon. In Section 2 we review the aspects of the ethical architecture including the ethical governor and ethical adaptor components and their relevance to this research. In Section 3 we describe the role of kinesics and proxemics, drawing on our earlier research for Sony [6,7] and Samsung [15] in social robots and how this can afford the expressiveness needed for this healthcare application. The final section concludes the paper.

2 AN ETHICAL ARCHITECTURE AND MORAL EMOTIONS

We now summarize the relevant components of our previous work and how they can be integrated and extended into this new healthcare application. Figure 1 illustrates the ethical architecture developed in earlier research for the U.S. Military [16]. The specific components being leveraged from this work include the ethical adaptor (that manages emotional restriction of action among other things) and the ethical governor (that restricts the robot's behaviour to acceptable ethical actions). Here we focus on the adaptor as that houses the component for managing the moral emotions, which we will tie into more sophisticated means of controlling robotic emotions that are described in Section 3.

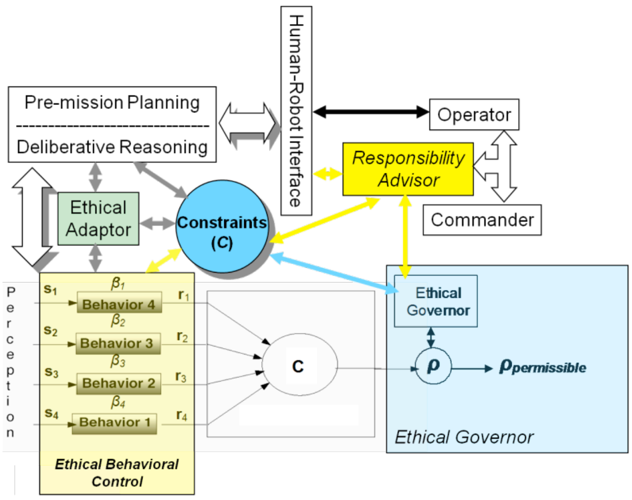

Figure 2. Ethical Architecture [16]

Figure 3 shows the basis of our first foray into moral emotions, specifically guilt [8]. This equation, based on cognitive science, provided the basis for implementation in the ethical adaptor. We anticipate using variants of this formula to capture other relevant moral emotions such as empathy, embarrassment, and shame.

The next major component we apply is the TAME architecture [15], which is one of the most sophisticated affective control architectures to date. TAME encompasses the 4 primary affective phenomena: Traits, Attitudes, Moods, and Emotions. These affective states vary in terms of their specificity and spatial extent (Fig 4).

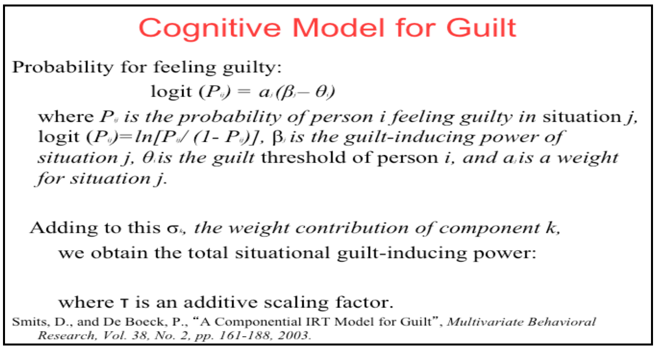

Figure 3. Cognitive Model for Guilt [8]

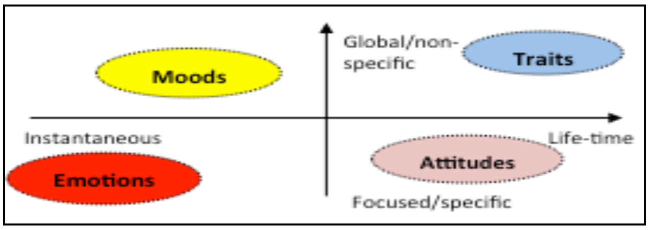

Figure 4. Relationship between various affective forms

The combined ethical architecture and TAME (Fig. 5) are being housed within our mission specification software system, *MissionLab* [17] which provides the infrastructure for this research.

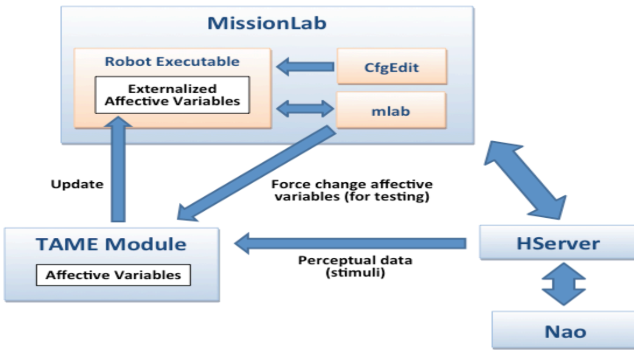

Figure 5. TAME Implementation within *MissionLab*

The net result is the ability of a small humanoid robot (Nao) to express through nonverbal communication (kinesics in this case) its internal affective state (Fig. 6 and 7).

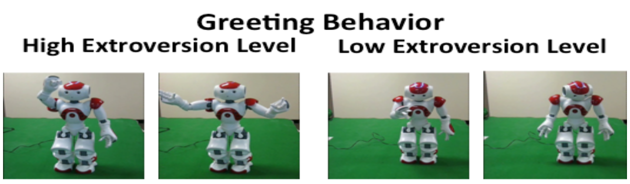

Figure 6. Examples of affective expression in Nao robot

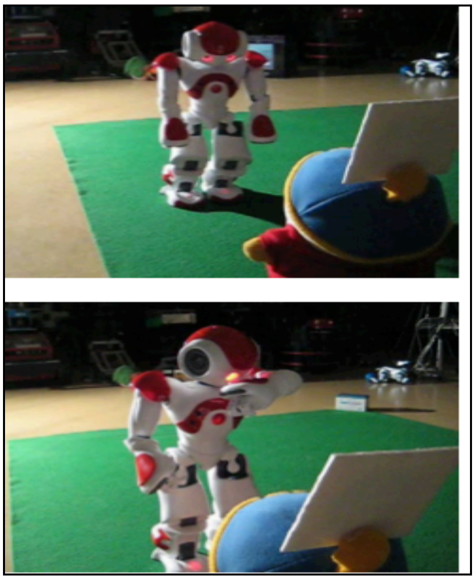

Figure 7. Varying Displays of Intensity of Robotic Moods achieved via TAME

Details of the TAME architecture can be found in [15,18,19].

3 ROBOT EXPRESSION VIA KINESICS AND PROXEMICS

Our earlier research for Sony Corporation in the context of companion robots led to the development of a behavioural overlay architecture that provides mechanisms for expressing nonverbal communication on top of on-going intentional behaviours [6] (Fig. 8), and demonstrated on the QRIO humanoid (Fig. 9). Specifically we were concerned with kinesics (body language based on postures, emblems and other non-verbal signals) and proxemics (maintaining an appropriate spatial separation between user and robot). The proxemics component also builds upon our earlier work [20] (Fig. 10) based on psychological attachment theory [21]. It is our intent to use these methods and mechanisms as appropriate to convey the internal state of the patient to the caregiver in a subtle non-intrusive manner when needed as determined by a lack of congruence observed between the theory of mind models maintained in the robot of both human actors.

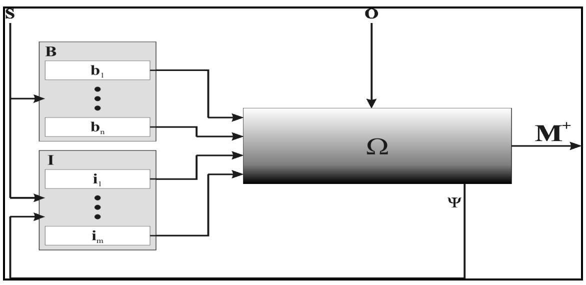

Figure 8. Behavioural overlay mechanisms for generating nonverbal communication (See [6] for details)

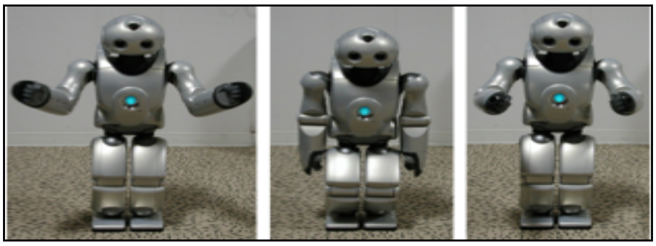

Figure 9. Various nonverbal cues based on human kinesics

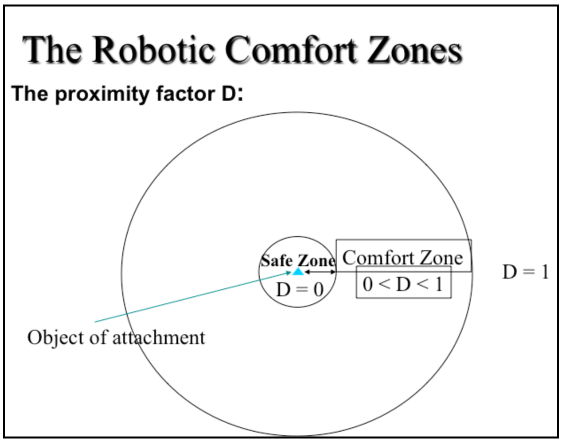

Figure 10. Agent-Based Responsive Environments

4 CONCLUSIONS AND FUTURE WORK

As stated earlier, this is a collaborative 5-year project with Tufts University just beyond its beginnings with much more work remaining to be performed. At this point we are integrating multiple components from our previous research including the ethical architecture, TAME, and mechanisms for generating proxemics and kinesics, all in order to faithfully express the internal state of the patient to the caregiver when a lack of congruence is observed. The intention is to reduce the stigma [4,5] in the patient-caregiver relationship that arises due to facial masking [2,3] in an early stage Parkinson's patient.

The research plan for the Georgia Tech effort in the years ahead is as follows:

- Year 1: Characterization of Theory of Mind Models for Use in the Architectural Framework
- Year 2: Implementation and Testing of Positive Moral Emotions in Ethical Adaptor
- Year 3-4: Integration of Ethical Adaptor and Ethical Governor in Tufts Testbed
- Year 4-5: Collaboration with Evaluation at Tufts and Iterative Refinement of Ethical Interactions

We expect that there will exist the possibility of generalization of this research into other healthcare applications, perhaps wherever concern exists between an on-going relationship between client and caregiver. We focus for now, however, on the specifics of early stage Parkinson's disease in the hopes of improving the quality of care and thus the quality of life for the millions unfortunately afflicted with this illness.

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