An Agent-based Game for the Predictive Diagnosis of Parkinson's Disease

(Demonstration)

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ABSTRACT

Existing Parkinson's Disease (PD) diagnosis relies heavily on doctors' observations combined with neurological exams. Such a technique is often inconvenient, infrequent, and subjective, which leads to a high misdiagnosis rate. As several cardinal symptoms of PD require long term observations, a technology platform which allows potential PD patients to exhibit related behaviors in a natural setting over long period of time is needed. In this paper, we describe an agent-based game for the predictive diagnosis of PD. Agents in this tablet based game provide companionship, encouragement, and analysis capabilities to help retain users' interest, and analyze their risk of developing PD symptoms based on their in-game behavior. The game has been launched together with a world renowned PD research centre for clinical trial. It can potentially provide a new dimension of longitudinal interactive behavior data to assist early and more accurate PD diagnosis in the future.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence - *Intelligent Agents*

Keywords

Parkinson's disease, predictive diagnosis, agents, game

1. INTRODUCTION

Parkinson's disease (PD) is a neuro-degenerative disorder affecting patients' motor and cognitive functions. An estimated 7 to 10 million people worldwide are suffering from PD [1]. Currently, there is no standardized PD diagnostic test. Doctors rely on their observations and neurologic exams to make a diagnosis. The misdiagnosis rate is reported to be 24% [7], which affects the effectiveness of treatment.

Interactive games have been found to be helpful for PD rehabilitation [3, 4]. Some cardinal symptoms of PD (e.g., *micrographia* in which case a patient's handwriting becomes progressively smaller and unintelligible) require long term observations to produce accurate assessment [5]. As players spend long periods of time in playing such games, it is also an ideal environment to capture and analyze changes in players' motor and cognitive functions to help predict their risk of developing PD. However, there is currently a lack of mobile game platforms suitable for PD predictive diagnosis.

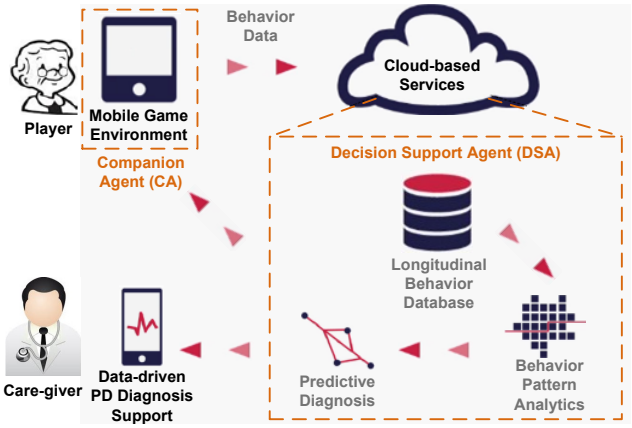

Figure 1: The conceptual framework of PG.

2. DEMONSTRATION CONTENT

In this research, we aim to infuse evidence based practice into the PD diagnosis process through a tablet-based interactive game platform - the *Pumpkin Garden* (PG)[1]. As shown in Figure 1, PG provides a farming-themed game environment on tablet devices. Interactivity designs in the game enable for a player to display behavior reflecting three of the cardinal symptoms of PD (namely movement synchronization difficulty, *micrographia*, and short-term memory loss) in an unobtrusive manner.

The interaction with the player is adjusted by an *companion agent* (CA) which is embodied as a non-player character as shown in Figure 3. For movement synchronization difficulty assessment, the player is asked to clear randomly appearing weeds in the farmland with fingers from both hands simultaneously (Figure 2(a)). For *micrographia* assessment,

[1]`http://www.youtube.com/watch?v=j1uiZpW2sVo`

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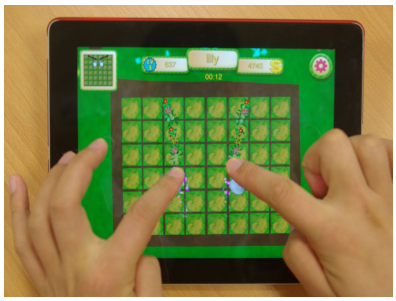

(a) Movement synchronization difficulty

(b) *Micrographia*

(c) Short-term Memory Loss

Figure 2: Interaction designs for assessing various PD symptoms.

Figure 3: The companion agent.

the player is asked to control a waterwheel to irrigate the field by repeating circular movements on the touch screen with one finger (Figure 2(b)). For short-term memory loss assessment, the player is asked to tap on the animals damaging crops in the field to herd them out of the farmland (Figure 2(c)). Each animal has a digit or an alphabet label. The player needs to tap the animal one by one following alternating digit and alphabetic orders in the correct sequence.

The in-game behaviors are gathered by the CA in the form of time series data during each of these mini-games. Based on expert knowledge provided by medical researchers, and evaluating the Value of Perfect Information [2] in the context that the price to be paid represents negative impact on user experience caused by asking the player to repeat a mini-game, the CA dynamically determines whether any of the mini-games needs to be repeated to acquire more data. The behavior data are sent to the cloud-based longitudinal behavior database where they are analyzed by a *decision support agent* (DSA). The DSA is incorporated with a fuzzy logic based approach to assess the indicators related to each of the three cardinal symptoms of PD based on the behavior data. The overall risk of developing PD is calculated and presented to the CA and the care-giver (if any) for actions.

3. DISCUSSIONS AND FUTURE WORK

Around 60,000 Americans are diagnosed with PD each year [1]. This number does not reflect the thousands of undetected cases. The estimated indirect cost per PD patient (e.g., lost wages of the PD patient and care-givers) is about US$30,000 annually in 2013 purchasing power [6]. The proposed platform may relief some of the burdens of PD care-givers and help the PD patients regain some productivity. The PG platform provides a low cost, easy-to-use, and objective way of predictive diagnosis for PD. The data collected from its on-going clinical trial will constitute the first interactive digital media personal wellness dataset documenting people's PD related symptoms. It may provide medical researchers with a brand new perspective in diagnosing Parkinson's disease, and offer insight into potential ways of technology enabled PD rehabilitation.

In subsequent research, we will investigate how to incorporate effective incentive and persuasive techniques into the companion agent in PG to reduce the occurrence of impulsive risk-taking behaviors among PD patients as a result of taking *dopamine agonist* medications.

4. ACKNOWLEDGMENTS

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