ASSESS MS: Supporting the Clinical Assessment of Multiple Sclerosis using Kinect

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ABSTRACT

We present an early prototype of the ASSESS MS system, developed to help health professionals more accurately monitor the progression of Multiple Sclerosis (MS). Specifically, the system aims to detect and quantify changes in motor dysfunction more objectively and accurately than human assessors. We focus on key interaction design decisions needed to deploy a machine-learning based system in a real clinical context.

Categories and Subject Descriptors
H.5.m. Information interfaces and presentation (e.g., HCI):

General Terms
Design, Human Factors,

Keywords
Kinect, Multiple Sclerosis, HCI, Machine Learning

1. INTRODUCTION

The ASSESS MS system is being developed to support the clinical assessment of Multiple Sclerosis (MS), a neurological disease that affects 2 million people. MS is an unpredictable condition that usually leads to physical and cognitive disability over a period of years. This can vary from a few years to decades. For this reason, health professionals who treat MS have a particular concern with cerebellar dysfunction which indicates progression of the disease and the need for more aggressive treatment. This can be marked by change in motor dysfunction, such as *ataxia*, a swaying of the body, and *tremor*, the oscillation of a body part such as an arm.

Currently, it is difficult to quantify changes in motor dysfunction as the current gold-standard measure, the Expanded Disability Status Scale (EDSS) [3], has high inter and intra rater variability [1]. ASSESS MS aims to detect and quantify changes in motor dysfunction more objectively and accurately than human assessors.

The project is a collaboration between researchers in Human-Computer Interaction (HCI) and Machine Learning, MS clinicians in two European countries, and a large pharmaceutical company.

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Figure 1: Assess MS system in use

2. SYSTEM DESCRIPTION

The ASSESS MS system records depth videos of specified neuro-assessment movements which are then pre-processed and analyzed offline using advanced machine learning techniques. The system consists of a recording tool and analysis algorithms.

2.1 Recording Tool

The recording tool is shown in Figure 1. It has a 21" patient-facing screen used to instruct patients in the neuro-assessment movements. A smaller tablet computer with touch screen capability is mounted on a mobile arm at the back of the unit. This is used by the health professional to position the patient, select the neuro-assessment movements to be performed, and complete the recordings. A number of features also allow health professionals to monitor these activities at appropriate points during the assessment. The screens sit in a tidy box on wheeled legs for ease of maneuvering with the Kinect mounted on top.

2.2 Analysis Algorithms

The current analysis algorithm classifies depth videos as of a patient or healthy volunteer. It relies on pre-processing of the depth videos with foreground segmentation and registration. Nearest neighbor inpainting is used to fill missing data and template-matching in depth space is used to detect and center the head. Customized randomized Forests and novel ensembles of randomized Support Vector Machines are used to discriminate landmarks in the depth videos that contribute to the classification. It has been validated on 1041 depth videos of both MS patients and healthy volunteers, achieving average Dice scores well in excess of the 80% mark needed to show validity [2].

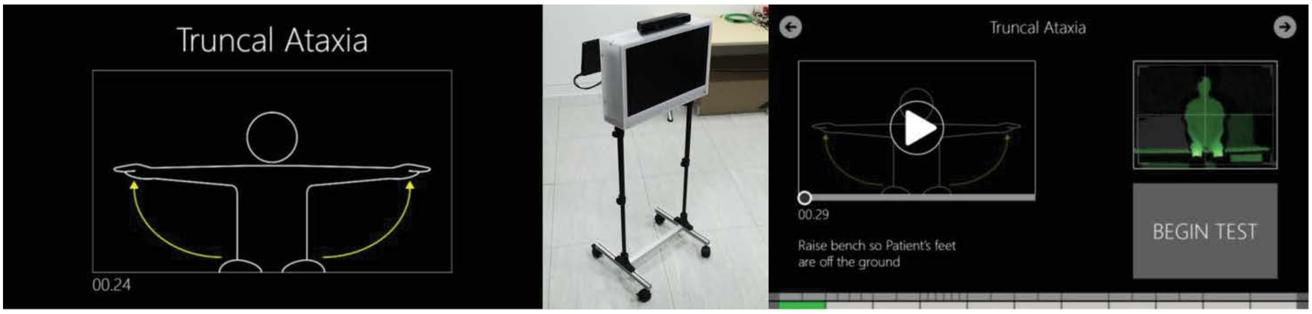

Figure 2: Images of a) an instructional animation (left); b) the ergonomic design (middle); c) the user interface for health professional

3. INTERACTION DESIGN

The ASSESS MS system is intended for deployment in MS research centers to support clinical trials in the first instance. The design of this first prototype system was done in conjunction with the clinical teams involved in the project and observation of assessments as currently carried out. This initial requirements gathering period raised a number of challenges in making a robust system for the clinical environment that could be used with patients with a range of physical and cognitive abilities.

A key interaction design challenge is to address these practical issues while maintaining the standardized data required for the machine learning techniques used in the analysis algorithm. We discuss how the design has addressed these needs.

3.1 Instructional System

There are a large number of variations in the way that a neuro-assessment movement might be performed. For example, the finger to nose test can be done by stretching the arm out to the side or in front of the body before touching the nose. To reduce variation unrelated to neurological symptoms that could dilute the analysis algorithms, we developed an instructional system.

Each movement is shown to participants with a simple animation. Variants (e.g. left side or right side) are then presented with a still screen (see Figure 2a). The animations use a line drawing of a person with yellow emphasis lines to indicate movement and its end points. These design decisions are based on the psychology literature which suggests that people learn movements best from simplified images with endpoints highlighted [4]. No visual feedback is provided to the patient during movements as this could influence neurological function.

3.2 Ergonomic Design

The system is designed as a single unit which can be easily maneuvered and stored in hospitals (see Figure 2b). The Kinect is mounted on top so that it can capture both sitting and standing movements. This choice increases the robustness of the prototype and the image pre-processing pipeline, but decreases the fidelity of some movements, particularly walking.

A tablet computer mounted on a movable arm is used by the health professional to carry out the recording. Its placement on the back of the unit encourages health professionals to stand behind or to the side of the unit during the majority of tests. This avoids the issue of the health professional occluding the camera view while interacting with the patient--an early problem we had. Its compact nature enables us to decrease the size of the overall unit and remove the keyboard.

A remote control is provided to operate the system when the clinician needs to stand near the patient to ensure their safety (e.g. when execute movements which require balance). The movable screen allows them to continue to monitor the recording process from any place in the room. A remote control, as opposed to a mobile touch screen, allows usage without looking so the health professional can maintain eye contact with the patient.

3.3 User Interface

The user interface, interacted with on the tablet PC, allows the health professional to control the flow of the assessment (see Figure 2c). They can skip a movement if a patient is too disabled to perform it or repeat an instruction video if needed. Most importantly, manual control of the interface allows for the pauses needed by the health professional to maintain interaction with the patient. This approach helped achieve a balance between the automation needed for standardization and the important role of health profession – patient interaction to encourage engagement.

The user interface also enables monitoring of captured video quality. This includes patient positioning, unnecessary objects in the camera view, and that protocol instructions are followed. These types of problems can render the recordings unanalyzable.

Next steps are to evaluate the prototype in a clinical context with patients.

4. ACKNOWLEDGEMENTS

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