Linking aetiology with social communication in a virtual stroke patient

Harry Brenton[1], Peter Woodward[2] Marco Gillies[3], Jonathan Birns[4], Diane Ames[2], and Fernando Bello[2]

[1] BespokeVR ltd (harry@bvrhealth.com)
[2] Imperial College London
[3] Goldsmiths University
[4] Guy's and St Thomas' NHS Foundation Trust

Abstract. *This paper describes an approach to building a virtual stroke patient which allows learners to visually explore connections between different stroke aetiologies and social behaviour. It presents an architecture that links a parametric model of aetiology to verbal and non verbal behaviour which can be manipulated in realtime. We believe that this design has the potential to consolidate understanding by allowing learners to systematically explore variations in clinical presentation. To the best of our knowledge, this is the first Intelligent Virtual Agent (IVA) that uses a parameterised behaviour model to provide an interactive examination and diagnosis of a stroke patient.*

Keywords: Intelligent virtual agent, virtual patients

1 Introduction

Virtual patients built using Intelligent Virtual Agents (IVAs) allow trainees to practice diagnostic and communication skills in a safe, standardised environment [1]. This gives entire cohorts of learners the opportunity to diagnose rare conditions, such as nerve injury, that cannot be feigned by an actor pretending to be a patient [2].

IVAs allow users to explore the impact of damage upon verbal and non-verbal communication. For example, a spoken request to look straight ahead reveals restricted eye movements that indicate a particular type of cranial nerve injury [3]. Similarly, hand gestures, body position, and gaze position can help to diagnose abdominal pain [1]. These systems use parameterised aetiology models to generate different presenting symptoms (aetiology is the study of the origins and causes of a disease or disorder). However, the variables cannot be manipulated at runtime, so learners are unable to explore the consequences of different aetiologies for themselves.

This paper describes a novel approach to building a virtual stroke patient that links a parametric model of aetiology to verbal and non verbal behaviour which can be manipulated in realtime. Correct diagnosis of a stroke (loss of brain function due to inadequate blood supply) is crucially important because misdiagnosing a stroke and administering incorrect treatment, can be lethal.

2 Instructional design and behaviour model

There are three modes of operation.

1. **Examination mode** The user administers the 11 items of the NIHSS test (table 1) and scores them between 0 and 4 as they progress through the simulation (figure 1).
2. **Debrief mode** Learners can consolidate learning by replaying encounters with virtual patients.
3. **Assisted discovery mode** The user interacts with either the 3D brain or the 2D CT scan to simulate the effect of a blood clot in an artery (figure 1d).

NIHSS item	**Interaction**
1. Response to verbal & physical stimuli	Reciprocal eye contact IVA tracks user's nose & fingers IVA responds to user's finger poke IVA responds to spoken instructions
2. Horizontal eye movement	IVA tracks user's fingers
3. Visual field test	User's finger tests visual quadrants IVA states number of user's fingers
4. Facial paralysis	User instructs IVA to show teeth User instructs IVA to close eyes User instructs IVA to raise eyebrows IVA's face responds to instructions
5. Arm stability	User instructs IVA to raise arm IVA's raises arm & holds pose
6. Leg stability	User instructs IVA to raise leg IVA raises leg & holds pose
7. Limb coordination	User instructs IVA to touch finger IVA touches user finger
8. Sensory loss	User pricks IVA with a pin IVA grimaces / verbally repsonds
9. Language skills	User instructs IVA to describe a picture User instructs IVA to name objects User instructs IVA to read a list IVA verbally responds to instructions
10. Generative speech (motor function)	User instructs IVA to read a list IVA verbally responds to instructions
11. Extinction and Inattention (optional)	User instructs IVA to close eyes User alternates touch on left/right User touches left & right simultaneously IVA verbally responds to touch

Table 1. The National Institute of Health Stroke Scale (NIHSS) and corresponding interaction with the IVA. The NIHSS scale quantifies the severity of a stroke between 0 (no symptoms) and 42 (a severe stroke).

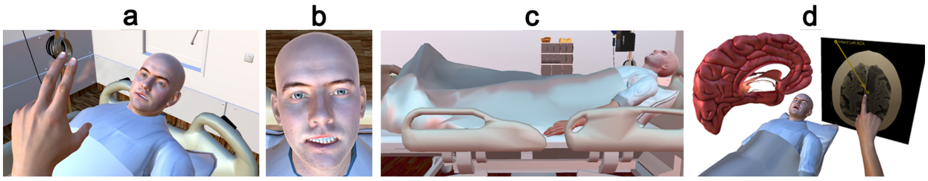

Fig. 1. Interacting with the IVA: a) a user raises two fingers to administer a visual field test; b) the IVA shows his teeth to test facial paralysis; c) the IVA raises his right leg to test motor stability; d) Selecting an artery on the CT scan or 3D brain simulates right sided partial paralysis in the IVA

Our architecture is designed to link between parameters of aetiology and parameters of complex social behaviour (figure 2).

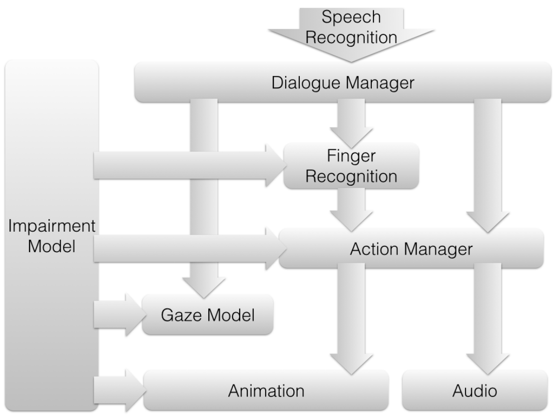

Fig. 2. The behaviour model used for the virtual patient. In each stage the behaviour is parameterised based on a model of the patient's impairment.

Impairment Model is a container for the key parameters of the patient's impairment that affect the visible behaviour. The following parameters are based on the NIHSS scale (table 1) which is used to control the different aspects of the IVAs behaviour: 1a: general verbal responsiveness; 1b: ability to answer questions verbally; 2: ability to track gaze in left and right hemispheres testing (a) motor control and (b) vision; 3: ability to recognise visual stimuli in the four quadrants of vision; 4: facial palsy; 5: motor paralysis in the arms.

Dialogue Manager takes in text from a speech recognition system and uses pattern matching to select from a series of possible responses based upon the NIHSS diagnostic protocol (Table 1). Each response triggers an action in one of the following behaviour controllers: utterances, finger recognition and gaze.

Action Manager generates actions (animation and audio) in response to user activity. Speech is generated according to the threshold of parameter 1b (ability to answer questions verbally): very high impairment results in no speech, lower impairment results in occasional speech.

Finger Recognition implements items two and three of the NIHSS protocol (Table 1) in which the patient tracks and counts the number of fingers held up in various quadrants of vision.

Gaze Model is a model of conversational gaze based on [4]. The proportion of time spent looking at the clinician varies across a number of conditions: 1) whether the clinician is speaking; 2) when the clinician administers a physical stimulus; 3) when the clinician asks the patient to follow their nose. All of these conditions are dependent on the impairment parameter 1a: general responsiveness. If the patient has an impairment in a hemisphere, all gaze behaviour is turned off when the clinician is in that hemisphere.

Audio is an audio player for speech responses. It is triggered when the impairment does not affect speech in the Action Manager.

Animation generates movement of the patient's face and body based on triggers from the action manager. All of the actions are parameterised blends between a full response animation and an unresponsive animation.

3 Conclusion

This paper presented an approach to building a virtual stroke patient that allows users to visually explore connections between aetiology and social communication. We believe that this method has the potential to consolidate understanding by allowing learners to systematically explore variations in clinical presentation. The next step is to conduct validation studies to assess the acceptability and accuracy of the simulation. Stroke has a devastating impact upon peoples lives, so any potential benefits of using IVAs for training are well worth investigating.

References

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