SUPPLEMENTARY FILES

Development of the Nao robot

The Nao robot (developed by SoftBank Robotics[1]) is an autonomous, programmable humanoid robot that is controlled by a Linux-based operating system called ROS (Robot Operating System) (Figure 1). The robot has capabilities for voice recognition and sound localisation (in-built microphones), multilingual text-to-speech synthesis (in-built speakers) and vision, which include facial and shape recognition (in-built high definition camera). The Nao robot was chosen for this project as it is widely used as a reference standard for research and education sectors.[1-4]

The SWOT analysis was developed from presentation of the Nao robot at the following events.

1. A public evening debate with a multi-professional audience including the computer scientists, academics, clinicians, social scientists, ethicists and members of the public (University of Liverpool*).*
2. A computer science workshop attended by computer scientists, data experts and healthcare professionals (University of Liverpool).
3. A round table discussion with five lay representatives (volunteers in palliative care) (the Winter Forum of the Palliative Care Institute Liverpool, University of Liverpool) and
4. Discussion following a presentation at an international conference (the Association of Palliative Medicine (APM) Annual Supportive & Palliative Care (ASP) conference, Belfast, 2017[5])

Figure 1: The Nao Robot

Programming the Nao Robot

The robot was programmed by a computer scientist (B.S) using Python (version 2.7) and NAOqi (the operating system that runs on the Nao). The Graphical User Interface was developed to enable an operator to control the Nao using a laptop (Figure 2). The Nao was programmed to convey ten emotions (relaxed, anger,

withdrawn/sad, lightly crying, heavy sobbing, happy/excited, scared, tired, laughing and dancing), which were demonstrated through manipulation of the posture, movement and speech.

Figure 2: The graphical user interface used to control the Nao robot

Once programmed, the Nao robot was demonstrated to computer scientists, and a palliative care physician. The set-up involved the robot in the robotics laboratory, on the flat surface floor, with the operator controlling the robot's movements with a laptop. The operator demonstrated the robot's speech capabilities (using text-to-speech synthesis) and emotional responses. A summary of the responses is provided in Table 1 and Figure 3.

SUPPLEMENTARY TABLE: Description of the emotional responses displayed by the Nao robot

	Description of action (originating from the prone position)
Relaxed	Basic awareness functions. Swaying action. Face tracking. White eye light emitting diodes (LEDs).
Anger	Disable basic awareness and face-tracking, red eye LEDs, play selected growling sound, simultaneously raise arms and fists up in aggressive manner.
Withdrawn/Sad	Turn away from the direction faced (if standing), disable basic awareness and face tracking, dark blue eye LEDs, lower head, arms remain by side.
Lightly crying	Disable basic awareness and face-tracking, cyan eye LEDs, play selected crying sound, hold arms to chest and raise and lower head to simulate sniffing.
Heavy sobbing	Disable basic awareness and face-tracking, cyan eye LEDs, play selected sobbing sound, raise hands/arms to face and shake head to simulate sobbing.

Happy/Excited	Enable basic awareness and face tracking, magenta eye LEDs, Nao says "Woo hoo!" raise arms in celebration before lowering again.
Scared	Disable basic awareness and face-tracking, yellow eye LEDs, play selected gasping sound, raise hand to mouth to simulate shock followed by raising the other arm to simulate hiding.
Tired	Disable basic awareness and face-tracking, white eye LEDs, play selected yawing sound, raise and then lower arms in a circle to simulate yawing.
Laughing	Enable basic awareness and face-tracking, white eye LEDs, play selected laughing sound, raise hands to torso and raise and lower head to simulate laughing.
Dancing	Left arm is brought up from side and brought outwards. Head looks left and back to centre. Action is repeated with left arm and head. Both arms are lifted up and down alternatively in front of body with head rocking from side to side.

Figure 3: Postures of the Nao robot to represent emotional responses

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