CASSM analysis of Robotic Arm

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This short document presents the CASSM analysis of a robotic arm as described fully by Blandford *et al* (2004).
We do not have access to real users of such devices, so the CASSM analysis is based solely on an existing written description of the robotic arm. In the following, key concepts and relationships are highlighted.

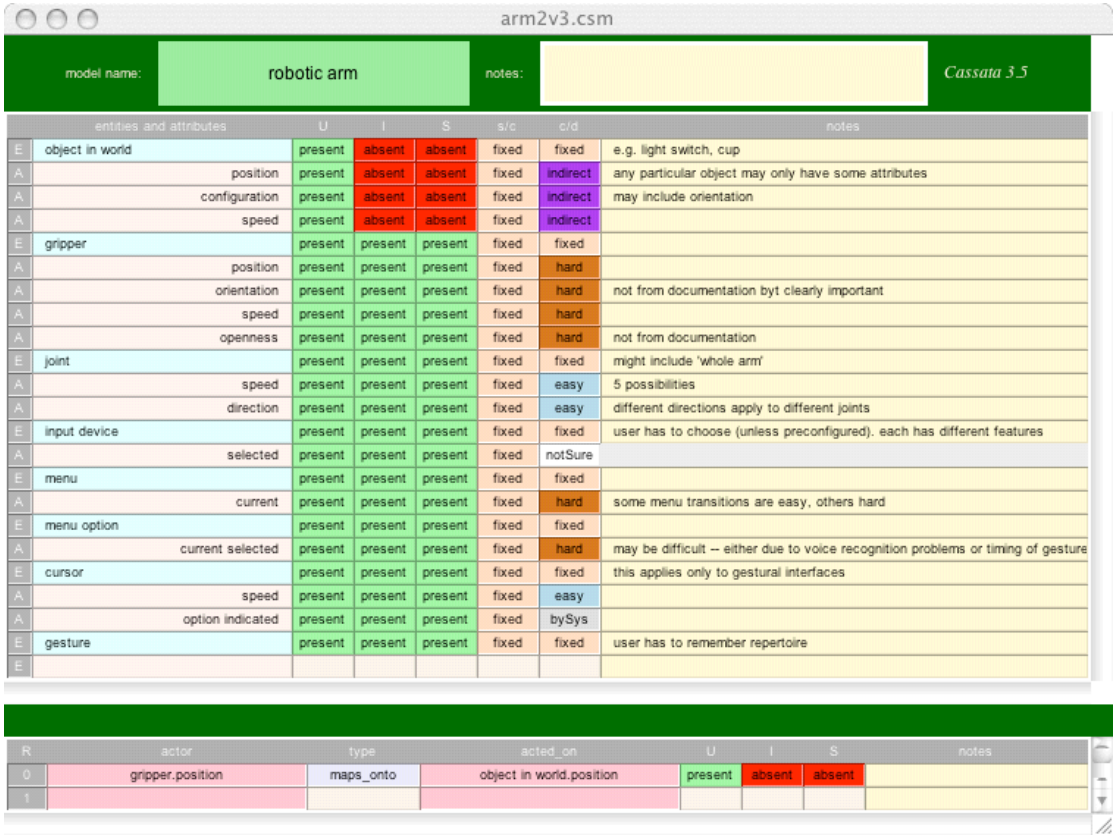
Source data:

"The AMMC at Middlesex University is currently developing a robotic manipulator for use by wheelchair-bound people. The arm is intended to be used in a domestic context for everyday tasks such as feeding and grooming, and has been developed primarily to prove that a sophisticated manipulator can be produced at a reasonable cost, with usability issues being considered informally if at all. The arm consists of eight joints, powered by motors, which can move either individual joints or the whole arm at once, via the input devices.
The input devices interface with a Windows-based application which in turn sends motor control commands in a special command language to a dedicated microprocessor, which actually controls the movement of the arm. For the purpose of the analysis, only one task is being considered, which uses only a small part of the interface. However, the task is one that will be very common to all users, and therefore will give valuable information on the usability of the interface. The task is to move the robotic arm to a certain position, without making use of any pre-taught positions, as though it were to be used to turn on a light switch. It is this kind of task that the developers of the arm consider to be a basic task, and that should be part of the core functionality of the interface. From the main menu of the application this covers the options move and movearm. Move allows the user to specify a particular arm joint and in what direction it can be moved, as well as controlling its speed. Movearm allows the user to move the arm as a whole in a particular direction. At present there is no feedback to the user other than that provided by the visual feedback of the arm's position.
The interface has not yet been fully implemented, but it is going to be implemented as a Windows application, using a menu format. Menu options will be selected in order to operate the arm. There are two methods of input, which can be used concurrently or as alternatives.
The gesture input system is based on a baseball cap with two sensors: one allowing movement forwards and backwards to be detected, the other allowing movement left and right to be detected. This allows a variety of unique gestures to form the gesture vocabulary. The gesture system is presently implemented so that a cursor moves along underneath the menu options continuously in turn, and if the correct gesture is made when the cursor is underneath a particular option, then that option is selected. Another gesture acts as a toggle between high and low speed of the cursor. A final gesture is an escape option, which automatically stops the arm if the arm is moving, and returns the user to the main menu.
The voice recognition system allows direct menu option selection simply by saying the menu option out loud. It is designed to be trained to individual voices, and needs resetting over time to do the way that voices change."

There are 8 arm joints, different possible directions depending on which joint is selected (usually 2, or 6 directions for the whole arm) and 5 speeds.

Analysis

This data can be tabulated and analysed as follows:



arm2v3.csm

model name: robotic arm notes: Cassata 3.5

	entities and attributes	U	I	S	s/c	c/d	notes
E	object in world	present	absent	absent	fixed	fixed	e.g. light switch, cup
A	position	present	absent	absent	fixed	indirect	any particular object may only have some attributes
A	configuration	present	absent	absent	fixed	indirect	may include orientation
A	speed	present	absent	absent	fixed	indirect	
E	gripper	present	present	present	fixed	fixed	
A	position	present	present	present	fixed	hard	
A	orientation	present	present	present	fixed	hard	not from documentation byt clearly important
A	speed	present	present	present	fixed	hard	
A	openness	present	present	present	fixed	hard	not from documentation
E	joint	present	present	present	fixed	fixed	might include 'whole arm'
A	speed	present	present	present	fixed	easy	5 possibilities
A	direction	present	present	present	fixed	easy	different directions apply to different joints
E	input device	present	present	present	fixed	fixed	user has to choose (unless preconfigured). each has different features
A	selected	present	present	present	fixed	notSure	
E	menu	present	present	present	fixed	fixed	
A	current	present	present	present	fixed	hard	some menu transitions are easy, others hard
E	menu option	present	present	present	fixed	fixed	
A	current selected	present	present	present	fixed	hard	may be difficult -- either due to voice recognition problems or timing of gesture
E	cursor	present	present	present	fixed	fixed	this applies only to gestural interfaces
A	speed	present	present	present	fixed	easy	
A	option indicated	present	present	present	fixed	bySys	
E	gesture	present	present	present	fixed	fixed	user has to remember repertoire
E							

R	actor	type	acted_on	U	I	S	notes
0	gripper.position	maps_onto	object in world.position	present	absent	absent	
1							

Key potential difficulties that emerge from this are:

- The user has to align the gripper with objects in the world (e.g. the light switch), in terms of position, speed and orientation. The mapping from the one to the other is non-trivial, particularly if the user has limited movement. In particular, the user may have difficulty judging how far away something is and getting the speed right on approach.
- For grabbing objects (not actually part of this task, but nevertheless important for others), the user has to get the orientation of the gripper and its openness right.
- (NOT directly from CASSM): while the user is looking at the gripper to get its attributes right, (s)he cannot also be looking at the screen to work with gesture control.
- Considering domain and device concepts, we see that the only domain-relevant concepts are those relating to an object in the world. Everything else the user has to do is about manipulating the device. The positions and movements of most joints will usually be of no direct interest to the user except when there is some obstacle to be circumvented. It is likely that the user's main interest is in the properties of the gripper, and that therefore the main task will involve moving the whole arm.
- Both input devices pose some difficulties: of accurate voice recognition, or of timely and appropriate use of gesture. This is likely to be simply something that users have to practice and learn to work with, but is nevertheless likely to pose initial difficulties.
- Some menu transitions are difficult.
- It may be difficult for the user to judge the direction to be set when the arm is contorted.

References

Blandford, A., Hyde, J., Connell, I. & Green, T. (2004) Scoping Analytical Usability Evaluation Methods: a Case Study. Working paper available from http://www.uclic.ucl.ac.uk/annb/CASSMpapers.html