**The Wooden Man Presentation**

[Title slide]

Ladies, Gentlemen, Robots, and non-binary organisms, may I present The Wooden Man.

[Picture of robot – screen showing a “smiley” face?]

Not as heavily armoured, or as powerful, as the Iron Man, but, being made of recycled kitchen worktop, and with a Raspberry Pi instead of a nuclear reactor at his heart, he is considerably more environmentally friendly and likeable. Having said that, his mission is to beat you into submission at a range of board games, and the sharp corners aren’t that cuddly.

[List of objectives/challenges]

The aim of the project was to create a robot which could actually play board games against a human opponent: detecting the actions of that opponent, and reacting with its own moves in real life. We chose games with similar playing mechanisms, such that robot control mechanisms would be largely shared, but which posed substantially different AI challenges. Tic-tac-toe is a very simple game, which can be solved completely in real time, even by a modest computer like the Pi. Nine Mens Morris is almost an extension of tic-tac-toe, but while it is technically solved (it should be a draw), it is too complex to solve in real time, so a more sophisticated, look-ahead and analyse, approach is necessary. It also has the merit of being relatively little known by the general public, giving the robot a better chance of beating you! Draughts is of comparable complexity mathematically, but has very different gameplay, and is better known.

We chose this project because it would bring together a range of technical challenges:

1. Woodie needs a vision system able to identify which game is being played, identify counters as they are placed, and convert the images into a board position. The images also need to be remapped to allow calculation of the position of objects in 3D space.
2. We wanted Woodie to be able to interact directly – in other words, to be able to play the games himself. Thus he needed a robot effector able to manipulate pieces and place them at specified points in space. Preferably the RIGHT points...
3. AI players would be needed to evaluate game positions, formulate possible moves, and ensure valid gameplay.
4. A core “operating system” would need to coordinate the different units: for example, getting a board position from the vision system, check its validity, and pass it to the AI. Once the AI returned the desired move, it would have to calculate what that required in terms of movements of the robot arm, and pass them to the motor controller.

[Vision System]

In the spirit of the Pi, we wanted to keep the hardware fairly cheap and simple, so we opted for a single webcam for the vision system. Since we wanted the robot to “meet you across the board”, we didn’t want to build a superstructure allowing a vertical view of the board, so we have mounted the camera on top of the monitor, giving it an oblique view of the playing surface. We need to be able to map this view into three dimensional space, to allow the robot to interact with it. Some parts of this problem we have solved mechanically, for example by having a horizontal board at the same level as the base of the robot, and some we have solved in software, using openCV for image transformation and detection of lines and circles. As you can see in this right hand image the computer’s view of the board looks like it was taken from overhead: it is also highlighting the circular counters it can see. In the screengrab on the left, we can see that it found 4 line intersects, allowing it to deduce that this is the tictactoe board. We can see that initially it could see the human’s opening move, and then later it recognised where it had itself played. This information is then passed to the main control program.

[Robot arm]

Initially we looked at using a commercial robot arm, but affordable ones were too small, and anyway it seemed more fun to build one. Our early research suggested it should be possible to drive a Lego Mindstorms system from the Pi, and the advantage of this is that the motors can both drive the movements, and act as sensors of their position. A big enough Lego arm proved difficult to build, because it flexed too much, so a wooden one was constructed. The base is a heavy turntable incorporating a ball race made of marbles.

Rubber bands try to pull the arm into a vertical position, and the motors mounted on the base pull against them to flex the arm. This means that a single motor for each joint can both flex and extend the arm.

The two motor-controlled hinges in the arm allow us to control the reach and height of the end of the arm. Effectively the turntable angle and the reach of the arm form polar coordinates over the playing area. To manipulate the counters, an electromagnet was mounted so that it would always hang vertically: this could be switched on and off using a fourth Lego motor.