Introduction
Current prosthetic hands have the same number of joints as human hands, and are capable of performing complex movements involving individual finger motions. However, a user’s ability to control the hand is limited by the availability of information on what they are trying to achieve.

Our aim is to enable natural control of prosthetic hands by feeding electrical signals from residual muscles through a biomechanical computer model of the hand to interpret the desired action. We have previously demonstrated that our computer model runs faster than real time [1]. Here we drive the model with EMG and test how well the model movement matches the intended movement. Moreover, we connect the model to a physical robotic hand, and test whether the combination of model and hardware is fast enough for prosthesis control.

Methods
The robotic hand used in this study was a Prensilia IH2 Azzurra. The computer model of the hand presented in [1] was simplified to match the robotic hand: the wrist was fixed, and all abduction/adduction degrees of freedom were removed, as well as all muscles that cross only the wrist. Four surface electromyography (EMG) sensors recorded the activity of flexor and extensor muscles in the forearm. Following [2], the EMG signals were rectified and processed through an exponential moving average filter. Participants were asked to move their hand to a number of postures, and their EMG signals were used to drive the model. In a separate experiment, we connected the model to the robotic hand, and quantified the time required for all processing steps.

Results
Preliminary data from one participant show that the model achieved the correct posture with 93% accuracy. When the robotic hand was included, its position was updated every 100ms, and within that time: (a) EMG was recorded and processed, which took an average of 1.6ms. (b) The model was simulated for 25 timesteps of 4ms. The CPU time required for each step was 0.49ms, thus the simulation speed was 9.3 times faster than real time. The 25 steps took an average of 12.3ms. (c) The model position was sent to the robotic hand, which took an average of 2.3ms. The overall time required was 16.2ms out of 100ms.

Discussion
We have demonstrated that our model interprets the desired action with high accuracy, and combined with real hardware, it runs fast enough for prosthesis control. In fact, the combination of all processing steps leaves 83.8ms out of 100ms free, which could be used to incorporate force feedback from fingertip sensors to enable control of grip.

References