STROMOHAB INTERNAL MEMO

DATE: 11/11/2008

TO: ADAR PELAH

CC: PHIL JEPSON, M ZHAO

FROM: MAT GILBERT

RE: HIGH LEVEL "TO DO" LIST BEFORE CLINICAL TRIALS

Notes Regarding Motion Capture Data Processing
- Mat Gilbert 11/11/08

This document details the main areas of the motion capture system that (in my view), require significant development work to bring the Stromohab system to the point where it is approximately ready for clinical trials. The sections below are presented in no particular order, though there are some obvious dependencies. The development periods beside each section are an optimistically conservative estimate – a guessed variance is around 33%. A rough guess would put the time to clinical trials critical path length at around 6 – 8 months. Additions/Amendments to this document are welcomed.

- **Create Skeleton Model (3 – 5 weeks)**
  - A jointed, hierarchal skeleton model must be created, in order to allow limb movement derivation from the motion capture marker data.
  - A number of features of the skeleton must be specified, principally defining the skeletons degrees of freedom – information about the number of joints, types of joint, and available joint movements must be specified. The more accurately the skeleton model represents the human skeleton, the more accurate all derived gait data will be (with obvious implications for clinical analysis). However, a more accurate skeleton will be a more complex one, which will lead to increased development time.
  - There are some publically available skeleton models around, and it may be possible to modify one of these for test purposes, although future commercial use may be affected by the use of a public skeleton.
  - Skeleton scaling to each individual patient is also something to be considered in this section, although is also described below.

- **Non-Trivial Mapping of Tracked Optical Markers to Skeleton (1 – 3 months+)**
  - There are numerous papers and PhD thesis(!) in the literature detailing methods and experiments regards this problem. Most methods require some user initial user intervention before automatically mapping markers for the rest of the session. Alternative approaches require highly accurate marker placement, with errors induced into the system by the operator – although even without these errors, our system cannot use this approach due to the lack of a skilled mo-cap technician on the end-user site. To date, little literature has been found detailing the mapping of markers in real-time – most research focuses on working with recorded motion capture data. Working in real-time adds complexity in that dealing with dropped and swapped markers must be done on the fly – a very

robust mo-cap system is required. Passive optical marker mapping is a very new field and may require a significant amount of development time, and may also even contribute to a final thesis.

- **Robust Marker Tracking/Rebuilding (1 month)**
  - Any optical system of this type suffers from occlusion and swapped markers (when two markers pass in front of each other their assigned IDs may change, leading to a foot marker being swapped with a calf marker for example. This will lead to incorrect derivation of skeletal movement). Our system is already working at the limits of the technology – to perform accurate gait analysis development time will have to be devoted to creating a robust tracking system that will eliminate swapped and dropped markers.

- **Skeleton Scaling (1 month)**
  - An incorrectly scaled skeleton will lead to inaccurate movement data. A quick survey of current literature suggests that most current automated methods (ie. methods that don't rely on human measurement of each limb) rely on parsing all captured data before utilising mean values to scale the skeleton. This is not viable in real-time, although there are possibilities of performing a series of calibration motions before beginning a session in order to scale a skeleton. Problems with this approach include the requirement for the subject to individually rotate joints and move limbs – previous research has focused on fit healthy actors, not patients with possibly limited mobility.
  - One method is joint estimation from centres of rotation (Scott's work), although again, this has inherent problems when working on the fly.

Additional Work Required (1-2 months)

Once the skeleton has been completed, additional consideration will have to be given to the rendering of the final avatar – again, realism specifications will have to be defined, answering questions such as exactly what level of realism is required to stimulate improvement in the patient. The realism scale reaches from the bare skeleton at one end, up to a fully rendered, layered graphic character, incorporating advanced 3D graphics methods such as skin and muscle deformation. Some graphics decisions will have to be made along the development route, to allow for testing of the skeleton, mapping, etc, and at a rough guess, another month should be allowed for learning the detailed control of a 3D graphics engine (OpenGL, XNA, DirectX/Direct3D, etc).

Conclusions

There is a significant amount of work to do before the system is ready for clinical trials, mostly involving the implementation of the motion capture using the NaturalPoint system. This is an area it appears previous work has not focused on, and hence the issues described above have not been investigated. Software (not including hardware) that does most of the above is currently on the market for prices starting from $11 000 to $16 000. (http://www.c-motion.com/products/Visual3D.htm). What we are trying to do, with the hardware we have available, is not easy, and may take some time to develop, though it is achievable in my opinion.