SOFT AND SEMI-SOFT PROTOTYPING IN ASSISTIVE TECHNOLOGY RESEARCH: REDUCING THE HUMAN UNKNOWNS WITHOUT COSTLY MANUFACTURE

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BACKGROUND

New dynamic support technologies need new user centered design tools. This paper describes the application of a valuable design exploration tool from information technology being applied to complex mechanical support systems.

Conventional iterative design processes[1] require a substantial investment of time in detailed design and prototyping before any evaluation can occur, particularly in the case of complex systems such as dynamic seating. The efficacy of a new concept cannot be predicted before a user evaluation.

There is a high risk that a lot of time may be wasted in exploring 'blind alleys' that are ultimately unsuccessful. Soft and semi-soft prototyping methods aim to reduce the investment in manufacturing required to assess the likely success of a novel approach by enabling concepts to be evaluated with a minimum of manufacture. soft prototyping: the first evaluation

The first evaluation of a prototype has the most uncertainty about its outcome. It is the highest risk evaluation, yet, first impressions of a device can have a substantial impact on the acceptability of a device. It would be beneficial to be able to physically evaluate the effectiveness of a concept without having to commit to substantial design and manufacture time. This would enable more concepts to be explored and would reduce the risk of failure of the first manufactured concept.

Soft prototyping reduces the risk of a hard prototype failing, and enables more concepts to be evaluated at an initial stage at no additional cost in hardware or detailed design and manufacture time.

Multiple concepts for a dynamic or static device can be simulated by a coordinated group of skilled people providing direct support to a client with their hands and bodies. Although seating and support strategies cannot be exactly simulated in this way, they can be simulated with sufficient fidelity to obtain further useful information about the likely success or otherwise of a dynamic support strategy.

An Example of Soft Prototyping

An example of the use of soft prototyping is the testing of multiple dynamic seating concepts for children with whole body extensor spasms. Following the partial failure of an initial approach, soft prototyping was used in the child's own home to evaluate several different dynamic support strategies, with trusted people present and no unusual equipment being introduced. This approach substantially reduced the child's anxiety.

The child was seated on his mother's lap, and secured in place by his mother's hands on his pelvis. The seat's dynamic backrest and footrest were simulated by the therapy/engineering team. The session was videoed for future reference and analysis.

The engineer gave clear instructions to the mother and therapist about how they should respond to the child's movement before he was seated on the mother's lap. For example, the therapist simulated a backrest that was sprung using a conventional compression or torsion spring. She was asked to progressively increase her resistance to the child's movement as his hips extended, and to decrease the force she applied as his hips flexed back to an upright sitting position.

This approach did not distress the child or his mother, it allowed variations on two different support strategies to be explored in detail within a short space of time, and required no previous design or manufacture, and the risk of failure of new hardware for the second previously untried seating strategy was substantially reduced.

<u>A Further Example of Soft Prototyping</u>

A novel dynamic foot support concept was evaluated by an adult with cerebral palsy who was experiencing extensor spasms. Experimentation with the concept, guided by the disabled adult (who communicated using an electronic communication aid) led to rapid synthesis of an effective support that improved his head control, decreased his underlying muscle tone and increased comfort. After the evaluation, it was clear what the specification for an appropriate mechanism should be, including the qualitative spring parameters to be used.

SEMI-SOFT PROTOTYPING: INTRODUCING A PHYSICAL STRUCTURE

A semi-soft prototype is a physical device that provides some structure and constrains its user, yet still relies on human support and adaptivity for important details of its dynamic configuration and operation.

The seat concept developed during the soft prototyping phase was built as a semi-soft prototype and was evaluated by two children with whole body extensor spasms. The prototype was simply a ‘floppy’ dynamic seat that used members of the therapy and engineering team to provide its spring and damping response, and to constrain the seat’s joint angles.

The evaluation was planned in detail prior to the child being placed in the seat, with each member of the team being given clear instructions as to what mode of support they should provide, how strongly they should resist the child’s spasms, and so on. The team practiced operating the seat before the child was placed in it. Different motion parameters were tested while the child was sitting, without the need to make any physical adjustment to the seat. The evaluation was recorded on video for future analysis. The video recording was important, as the team members were concentrating on correctly supporting the child during the evaluation procedure, and not on observing the child’s responses.

The results of this evaluation led to the design of a hard prototype that incorporated the dynamic features evaluated in the semi-soft prototype. At the time of writing, the hard prototype has been successfully evaluated for a week by one child with only very minor changes to static dimensions after an initial short evaluation. A longer evaluation by the second child is planned.

DISCUSSION

In this work for previously unseatable children, soft and semi-soft prototyping has enabled the synthesis of a novel support strategy without numerous hardware iterations. The ability to rapidly evaluate different dynamic configurations in a low stress environment for the child who is afraid of seats has enabled synthesis of a novel approach to seating that has been shown to be effective in slightly over one year.

Important considerations are a clear understanding of what concepts are to be evaluated; a well-defined evaluation procedure; clear and well understood roles for each member of the team; and independent observation and video recording of an evaluation. A voice commentary by the lead evaluator can also be helpful when reviewing video.

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