

## **CRITIQUE-2**

### **Introduction and research summary**

The paper focuses on providing an interaction with heavy objects in virtual reality using Electrical Muscle Stimulation (EMS). The idea was to render virtual objects by pushing the user's hands with a force in the opposite direction by actuating the user's muscles with EMS. The design mainly focused on making the virtual object believable to the user, impermeable, consistent with sound, visual, haptic effects, familiarity with the virtual objects as the real world objects. The research paper talks about two studies.

The first user study describes about the types of EMS effects (repulsion and soft designs). The repulsion design had electro visuals and also sends a counter-force pushing the user's hand backwards and removing it from the user which made this design work for impermeability and consistency factors. The other design discussed was the soft design which allowed the user to penetrate objects by 10cm and repel back carefully due to a magnetic force. This design worked well but was not as good as the repulsion design based on the experiments. The applications of the two designs on virtual objects in virtual reality have also been listed.

The second user study describes about the user experience, user preferences and their comments, questions, reactions on all the different designs. According to the discussion, the EMS has added to the user's experience.

### **What I liked**

I liked the first section of the paper (the first user story) about the different types of designs (repulsion and soft designs). The paper listed out how the first design, that is, the hard object design did not work due to the strong and long EMS actuation when the user pushed against the solid wall and then listed out two possible solutions, that is, the repulsion design and the soft design which would work. The idea of the design has been explained in detail with images of visuals and also how it could increase the user experience has been discussed. The paper evaluates these designs by first giving a hypothesis of what they expect the results would be for different designs and conduct experiments with a variety of participants having different experience levels using the VR or EMS effects. The hypotheses were also evaluated by having a comparison analysis between the different hypothesis predicted and what the users experienced was discussed. The questions as well as the user comments after participating in the experiment have been quoted which makes the hypothesis, arguments and analysis more relatable. The paper illustrates how the soft design and repulsion design together create haptics for different virtual widgets, like buttons, projectiles, sliders, walls, liquids and user actions such as, push back widgets, lifting and dropping widgets. This section had a complete explanation of the design ideas, the experiment, hypothesis, applications which gave me a complete picture of the author's idea on providing Haptics to walls and heavy objects in virtual reality by means of electrical muscle stimulation.

## **What you disliked**

The related work section did not give me a clear idea of why the other products like the pneumatic gloves, vests, robot arms, exoskeletons, FlexTensor do not work well when compared to the author's idea. A description of what these gloves or vests do has been described but the paper does not include the parameters that failed in each product and how could the EMS wearable overcome those problems. The authors should have described about the product, the failure scenario of that product and why the EMS solution would excel.

The experiments were conducted on only 14 participants for the first user story which might not be a good number to analyse the hypothesis or the idea. More number participants would result in more accurate results.

The conclusion section should have a brief summary of where the idea fails and where the idea would excel also the contributions the idea made. The research paper just says that they proposed a new approach with EMS. A brief summarization would give users an overall conclusion of the work done and the contributions made.

## **Questions**

When the user pushes his hand towards an elastic membrane would it still give a less intense repulsive force according to the soft design instead of a high intensity repulsive force?

How would the soft design work for very thin membranes? Would the penetration of 10cm work in this case?

Why does the user experience a backward force when he moves his hand towards water? The viscosity isn't too intense and in real world our hand can go through water.

## **Conclusions**

The idea to render virtual objects by pushing the user's hands with a counter-force by actuating the user's muscles with EMS is very interesting since it adds to the user experience by making the virtual objects impermeable and also consistent to the visual and haptics. Different concepts such as tactile stimulation, force feedback and physical props were new learning points.