

# Virtual rehabilitation for upper body extremities using Kinect

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## **Summary:**

*Objectives* : This work provides a low cost virtual rehabilitation solution that can simulate a repetitive exercise and presents a pilot study of effectiveness of a customizable game designed for Xbox Kinect on shoulder rehabilitation by improving hand-eye co-ordination and muscle flexion

*Methods* : A ball tracking game was designed to test the reflex times of the subjects. The game requires the subjects to use shoulder movements to track a ball several times for 30 seconds per level. The game has 4 difficulty levels simulated by reducing ball size. The testing spanned for 4 days per subject. The reflex times were recorded on each day to monitor the improvement. Study involved a group of 23 healthy volunteers and a single subject with shoulder injury

*Results* : For the average reflex times obtained from these tests, ANOVA and T-test statistical analysis were done to find the improvements in reflex times from day one to day four. Statistically there was significant improvement in the reflex times for both arms with  $p < 0.05$

Significant improvement in the weaker arm of injured subject establishes the effectiveness and potential of this system.

*Conclusion* : It was found that the game was effective in both case studies. The game can also be easily customized based on the subjects needs. Use of Kinect makes it a potential low cost, in house rehabilitation device. The game is interactive and capabilities such as remote monitoring can be easily integrated into it.

## **Aim of Research :**

To propose an in-house, cost effective solution to enable virtual rehabilitation that can provide a simple alternative for conventional therapeutic methods. To understand its usefulness in addressing shoulder rehabilitation that is attained by improving target subject's reflex reaction through repetitive trials. To achieve our set goals, we first designed a fun interactive game for Kinect. We then tested the game on a set of healthy volunteers as part of the pilot study to understand its acceptability. After the pilot study we made a case study by testing the system on a participant with shoulder injury. Finally, statistical analysis was made to show the improvements in resulting from the study.

## **Method of Research & Progression :**

The device used for this research is Kinect (Xbox 360 controller, Microsoft) which is camera based sensor with skeletal tracking capabilities. Exploiting this feature, the ball tracking game was designed. Figure.1 shows the data flow diagram of the game's algorithm. The objective of the game is to track a ball that

randomly appears on the screen. The player gets only 30 seconds to track the ball as many number of times as possible. There are four levels in the game. At each level, the ball size shrinks and thus increases difficulty of the game.

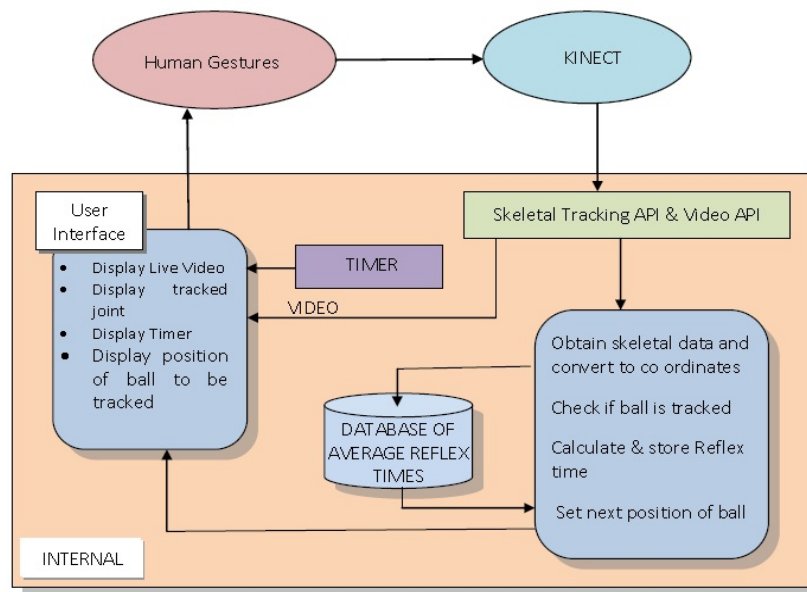


Figure 1 : Data flow diagram of the game algorithm

Every volunteer was asked to play the game for four days and the progress was monitored on each day. The procedure followed for these four days are as follows :

**Day one:** The experiment begins with a briefing of procedure, safety practices and a live demonstration. The subjects are then asked to play the game and the average reflex times are recorded. This is repeated one more time with a break between each trial, but the timings are not recorded during the second trial.

**Day two:** After another briefing session, the subjects are asked to play the game and the timings are recorded. After a break, they are asked to play the game again for practice.

**Day three:** Similar to day 2, the subjects are asked to play the game and reflex times are noted and after a short break they are asked to play the game again.

**Day four:** The same process as day three is repeated. But after the completion of the experiment, the participant is asked to fill out a post experiment questionnaire.

**Results of Research :**

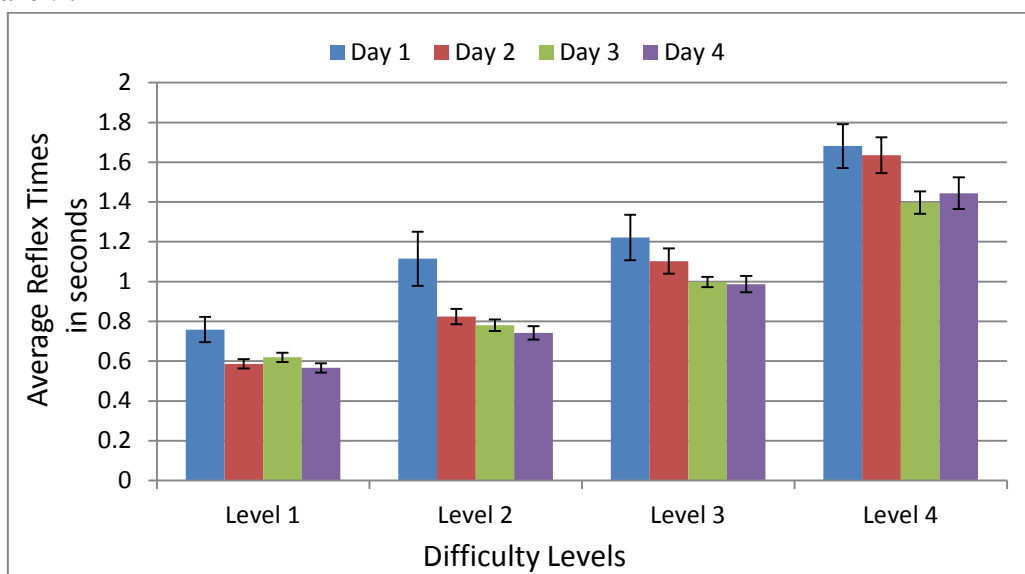


Figure 2 : Change in mean Right arm reflex times for healthy volunteers

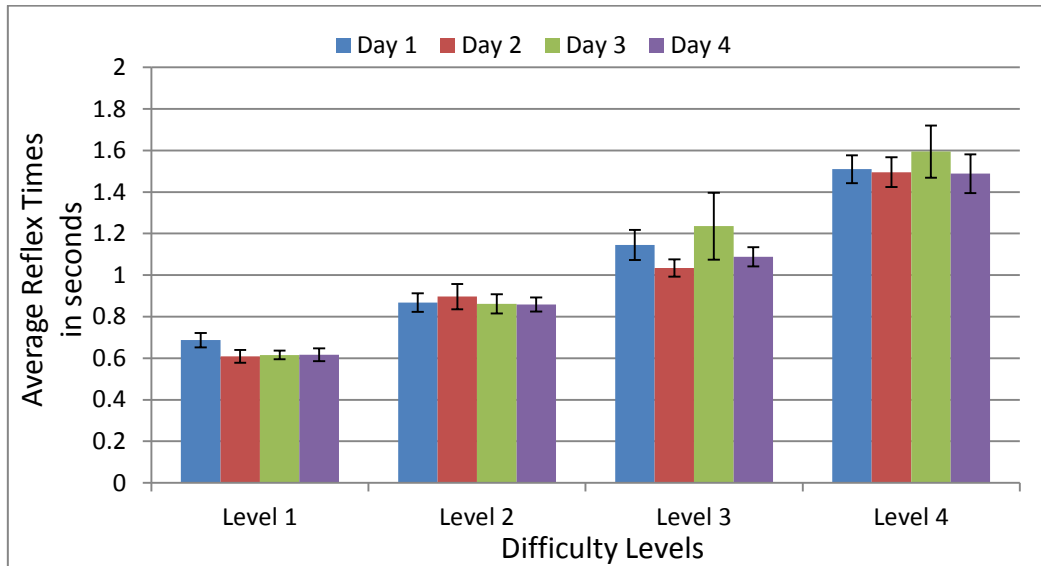


Figure 3: Change in mean Left arm reflex times for healthy volunteers group

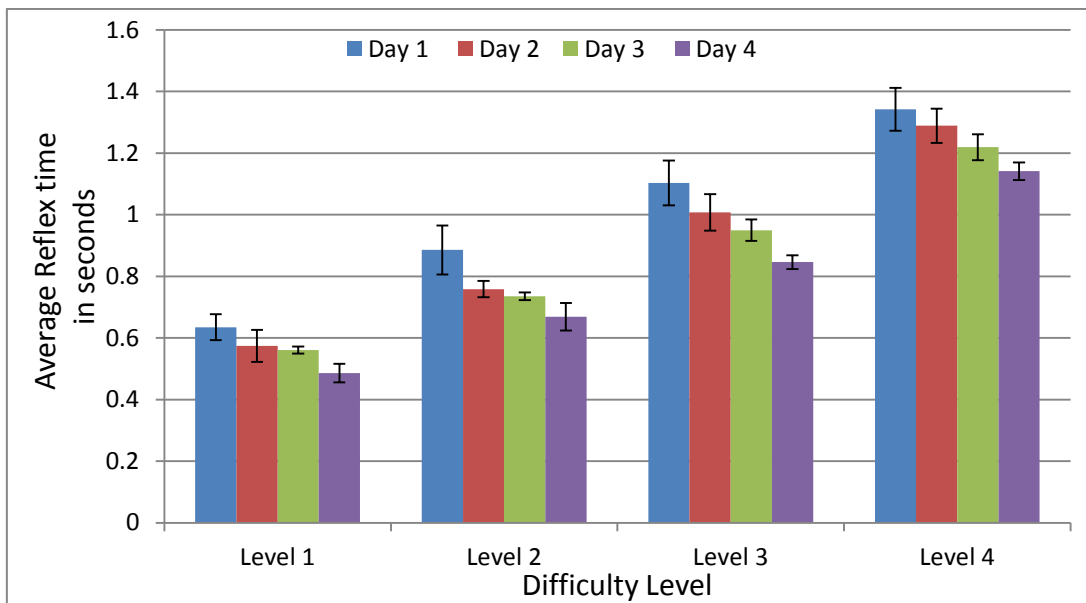


Figure 4 : Change in mean Right arm reflex times of Subject X

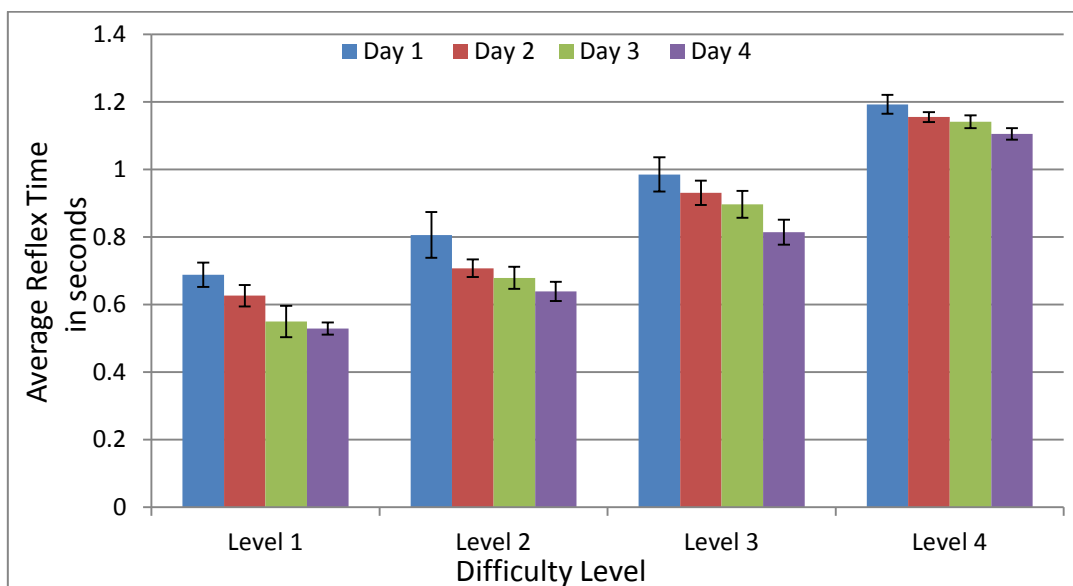


Figure 5: Change in mean Left arm reflex times of Subject X

The results shown here are obtained from a group of healthy volunteers aged between 21 and 30. A total of 23 subjects tried the experiment using their right arm and 16 subjects tried the experiment using their left arm. Comparing the two, the mean right arm performance is found to be better than left arm. Figure 2 shows the variations for right arm and figure 3 shows the variations for left arm reflex times of healthy volunteers groups from day one to day four. Comparing the Average Reflex Times (ART) from day one and day four, right arm shows significant improvement. The left arm however, shows very minimum improvement. ANOVA – analysis of variance was used for statistical analysis, with each level being the between-group independent variable and each day as within-group independent variable. From the analysis for right arm, Level 1 [ $F(3, 88) = 5.22, p = 0.0023$ ] and level 2 [ $F(3, 88) = 5.22, p = 0.0023$ ] significant improvement has been observed. For Level 3 [ $F(3, 88) = 2.47, p = 0.067$ ] and Level 4 [ $F(3, 88) = 2.64, p = 0.0547$ ] close to significant difference was observed. The ANOVA analysis shows that the means of all days are statistically different from each other. This was further supported by the t-test analysis (not shown here), which shows that the data was significantly different between day one and day four.

An individual case study on a subject (Subject X) aged 25, suffering from bilateral supra spinatous tendonitis caused due to excessive strain, was done. Despite the injury, the subject was able to show good performance. Figure 4 and figure 5 show his right and left arm performances respectively. Although inconsistent, we can see significant improvement from day 1 to day 4 over five weeks. Similar ANOVA analysis as done for healthy volunteer group was done for subject X's data. For right arm, the p-values were found to be very close to 0.05 with Level 1 [ $F(3,16) = 2.75, p=0.076$ ], Level 2 [ $F(3,16) = 3.6, p=0.036$ ], Level 3 [ $F(3,16) = 4.41, p=0.019$ ] and Level 4 [ $F(3,16) = 2.9, p=0.067$ ] showing close to significant improvement. Similarly for left arm, it was found that the data is close to significantly different for levels 2, 3 and 4 as the p-values are found to be very close to 0.05 with Level 1 [ $F(3,16) = 4.47, p=0.018$ ] Level 2 [ $F(3,16) = 2.86, p=0.069$ ] Level 3 [ $F(3,16) = 3.03, p=0.059$ ] and Level 4 [ $F(3,16) = 3.1, p=0.055$ ]. The statistical analysis of Subject X's injured arm data revealed that there was close to significant difference in the data from day one to day four over all trials which lasted for 5 weeks. This implies that the game is well suited for target application of virtual rehabilitation. And also proves its effectiveness in improving the hand-eye co-ordination and improved muscle flexion.

### ***Future Areas to Take Note of, and Going Forward :***

The study can be extended to test on elderly subjects, subjects with hemiparetic conditions and also for prosthetic rehabilitation. An improved interactive interface which is graphically more appealing would help in maintaining user's interest. Longer duration and higher number of case studies would help in further understanding of the effects on the game. Tactile sensors can be used to obtain stress maps to compare virtual and conventional physiotherapy. The stress analysis would benefit social robotics research to achieve more human like movements.

### ***Means of Official Announcement of Research Results :***

- Journal Paper
  - Disability and Rehabilitation : Assistive Technology