Poster: Studying the Role of Kinect as a Multi-Sensory Learning Platform for Children

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Abstract
According to the theory of Embodied Cognition, our behavior is a result of real-time interaction with surroundings, our cognitive skills, and the nervous system. From this perspective, researchers are considering a learning environment which promotes physical activities to achieve cognitive tasks. Such Natural User Interfaces (NUI) make use of gesture-based sensors like the Microsoft Kinect. Yet we lack in-depth studies of how they improve the learning process. In this paper, we present observations of two deployment studies which focus on different roles that NUI can play as a part of learning activities. We deploy the Kinect based applications:- Yoga Soft: A Digital Yoga Instructor and Mudra: A Kinect based Learning System in real life scenarios. The first study is conducted at residences of pre-adolescent children in Gurgaon, India. The second study is conducted at an education center specializing in the care of kindergarten children in Pilani, India.

Author Keywords
Education; Interactive Applications; Natural User Interface

ACM Classification Keywords
K.3.1 [Computers and Education]: Computer Uses in Education - Computer Assisted Instruction; K.8.0 [Personal Computing]: General - Games

Figure 1: A participant learning an *asana* by following audio-visual instructions

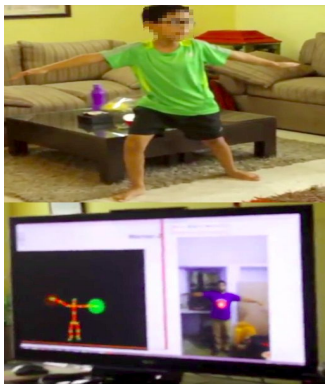

Figure 2: The Application Interface shows the user's real-time posture (left) and training video (right).

Introduction

Today, the society is driven by innovations in technology and with rapid developments in technology, the approach to teaching is constantly changing. Everyday digital computing is transforming education by integrating smart-boards and tablet technology in classrooms [5]. There is no doubt that in today's digitally enhanced society, there is a need for children to get equipped with technology from the very beginning.

The adoption of new technologies, especially the Microsoft Kinect has received an enthusiastic reception across schools. The Microsoft Kinect sensor is a high resolution (low cost) depth camera, which is able to track hand and body gestures. This type of Natural User Interaction (NUI) is appropriate for children as it promotes improvement in motor planning, execution skills and hand-eye However, most of the existing applications for Kinect don't focus on the goal of enhancing learning in children. Although the integration of NUI technologies have already begun, questions regarding the suitability of software systems that claim to meet the needs of children and teachers are still unexplored.

In this work, the role of NUI as an illustration to Microsoft Kinect is investigated. We study its impact on children's creativity, motivation to learn and easy of usability.

Using Kinect as a Learning Platform

The KinectV2 sensor can track various joints and their distance from the horizontal plane [4]. The joint locations can be used to track the hands, legs, torso and angles between them.

The proposed applications are developed using Kinectv2 sensor for Microsoft Windows 8 and above. The hardware API is accessed using PyKinect2. The applications are based on Pygame engine which allows real-time game development. We make use of Microsoft RxPY to handle Kinect's data as event streams. Further, custom APIs as web apps are deployed on Microsoft Azure to monitor the development of children.

To observe and study the impact of NUI with Kinect on learning, and cognitive skills, the proposed platform is analyzed across different environments and context. The following section discusses the different contextual studies undertaken to study gesture-based interactions.

The Digital Yoga Instructor: Yoga Soft

Yoga Soft is meant to guide a practitioner through all the steps of an *asana* (yoga posture). The system has a database of many *asanas* or postures. It is explicitly programmed to recognize a particular *asana* by tracking the motion and orientation of the torso, legs, and arms. It guides the user towards the particular posture in multiple stages. The different postures are encoded in the application in terms of the relative positioning of different body parts. Yoga Soft provides real-time feedback (Figure 2) in the form of voice instructions so that the person can focus on his *asana* instead of looking at the screen for subsequent instructions.

Empowering children with Kinect learning games: Mudra

Children's learning ability is hindered if they are in anxiety. The *amygdala* which processes emotions [1] takes a defensive stand by obstructing information flow. Therefore it is very important to make sure that children are motivated and enthusiastic to learn. Traditionally, it is supposed that physical activities can provide the break to rejuvenate the spark to study. Mudra is developed to provide children a fun-based learning platform by coupling physical activities and education, a methodology known as head-fake learning

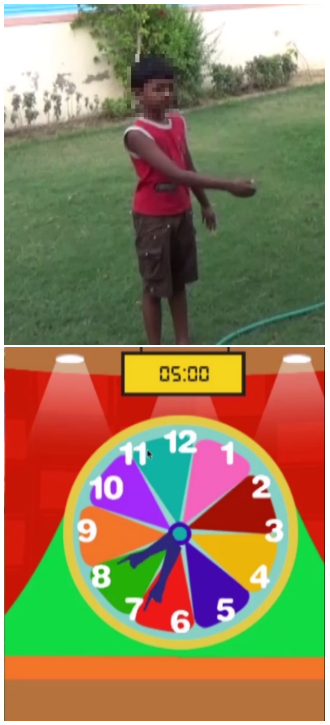

Figure 3: A participant (above) using his hands to match the time shown on his screen (below).

[6]. We develop touch-less games which require human-computer interaction mediated by Kinect.

The application is based on head-fake learning [6] which connects learning with fun. We employ it to help children to improve their motor planning, concentration, and memory skills [3]. Educational games focusing on arithmetic and linguistics are developed using adaptive learning to monitor a child's development and accordingly adjust the difficulty level. Moreover, a score is provided to give instant feedback.

The platform included 3 games for the study. $1)$ Tell the Time (a participant matches the displayed time using his hands as that of an analog clock, Figure 3), Aftermath (given an incomplete equation, the user need to fill the appropriate operator $(+, -)$ using his arms to make the sign) and Catch the vowel (the user learns to differentiate between vowels and consonants by catching vowels, Figure 4).

Contextual Studies: Result and Discussions

To prepare for the study visits, we requested some children (after taking permission from their parents) in a residential society in Gurgaon, India to volunteer to learn 3 different Yoga *asanas* (Tree Pose, Warrior Pose and Triangle Pose) with Yoga Soft. Similarly, the study visit for Mudra was conducted at Pilani, India in education centers specialized in the care of kindergarten children.

Throughout each study visit, study data are collected in the form of observational notes, video recordings, and photographs of learning activities. The application's API on Microsoft Azure automatically saved quantitative data regarding the performance of students. In addition, we interviewed the teacher or guardian about their perspective and experiences with the application.

According to the observation and findings in both the contextual studies, Kinect was perceived as an enjoyable experience by most of the participants. In general, children didn't find any difficulty in interacting with the application.

We consider study participants belonging to age groups 5-8 for several reasons. Firstly, at this age children have much better learning capabilities [2]. Secondly, if a child can learn by following voice commands of the digital assistant, then it is indicative that the system is competent in communicating with the user in general.

Context 1: Yoga Soft
We explore Yoga Soft with pre-adolescent children in a residential setting to simulate a controlled environment. All participants were requested to practice all the three different yoga *asanas*:- Tree Pose, Warrior Pose and Triangle Pose. Yoga Soft supports two languages:- English and Hindi (mother tongue for children).

Context 2: Mudra
The research on Mudra was conducted with kindergarten children. Children were instructed to match the time using their hands as that in an analog clock (Figure 3). We also tested their ability to differentiate between vowels and consonants (Figure 4). Some of the relatively elder children were given basic arithmetic problems. All the games involved gestures. Teachers were allowed to choose appropriate games for different children.

Results

We find a number of similarities and differences between the interaction experience with Yoga Soft and that of Mudra. In general, children were excited to see the new format of learning. The voice recognition and feedback system of Yoga Soft especially amused the participants. With regard to games such as Aftermath, it was observed that children's

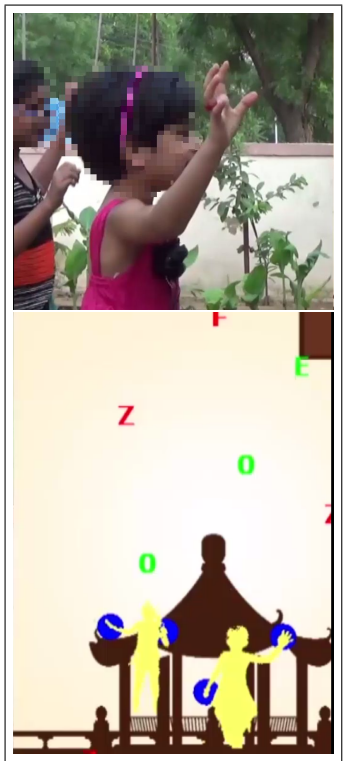

Figure 4: Two children trying to catch vowels (above) and the corresponding visual (below) they see on their screen.

performance was enhanced and the general fear against math problems was reduced. Similarly, with 'Catch the vowel', children improved their hand eye coordination and could successfully recognize vowels. Use of natural interactions and gestures helped the children direct their impulsive and hyperactive nature in a positive direction. As they were allowed free-play with the application, none of the children gave up despite some wrong answers. Thus the application was instrumental in provoking the creative side of their personality. In contrast to traditional teaching, there is no bias or favoritism in a software-based learning platform. Rather the platform was developed to adapt itself to the learning ability of different children.

However, we observe the following disadvantages of using NUI for education. $1)$ Many children were not able to follow intricate instructions like *"Turn your right foot 90 degrees outwards with your toes pointing in line with the shin"*; or *"Align the center of your right knee cap with the center of your right ankle"* (second step of Triangle Pose). $2)$They were able to follow only after looking at the demonstration video on the screen. This introduces a limitation on the system as in certain *asanas* the user might not be able to look at the screen. $3)$ Moreover, Kinectv2 has many "blind spots" i.e. if certain parts of the body are occluded then it cannot ascertain their orientation and position. There is a high risk of injury in practicing yoga *asanas* without complete guidance.

Conclusions

This work presents the results of deploying natural-interaction based user applications in educational centers and residences. Based on the qualitative comments, it was observed that children's interest and motivation level towards learning increased as suggested by the above study. The study suggests that Kinect can be used to promote verbal skills, motivation and free-play. But at present Kinect is not suitable for providing guidance for physical recreational activities like Yoga. The future work may address the design of Natural User Interfaces (NUI) so that it can serve as an valuable assisted tool to children as well as teachers. In future, it would be interesting to see how NUI evolves to address the issues as discussed in this work.

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