# Virtual Training System for Crawling Skill in Infants Using Mapping 2D: Preliminary Test

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**Abstract.** This paper describes the development of an interactive virtual tool, in order to encourage the ability to crawl in infants. The virtual environment in the system is implemented with the graphics engine Unity3D. The application is tested in the MagixBox platform with a high brightness projector. The environment has colorful and novel designs which are projected on a suitable floor space. User can interact with the projection due to the mapping that makes the infrared sensor and HD 2D camera in MagixBox. The sensor will continually scanning the objects that are close to the projection. The system helps in the process of activities record and saving important data for the assessment by the specialist.

**Keywords:** Virtual system · Therapeutic exercise · Unity 3D

## 1 Introduction

Crawling is moving capability baby through a quadruped position. This type of locomotion gives the child the opportunity to gain experience and basic movement patterns necessary for motor maturation. The crawling start plays a vital role in early development that involves changes to perceptual, cognitive, language, social and emotional level [1]. The transition to crawling supported on hands and knees can result in increasing the strength of the arms of infants. Diagonal or alternate crawling patterns are more efficient and stable. This sequence is useful for the walking preparation [2].

Cerebral Palsy is one of the major problems in decreasing skills and movements coordination; often the abilities that decline can be crawling skill [3]. For the treatment and therapy in infants have been used some virtual reality novel systems with other technological devices [4].

A study by the intervention of a mobile robot that helps children in crawling activities. The robot detects and analyzes the movements of the limbs. When the robot recognizes a valid movement moves in the same direction [5]. For tracking movement during crawling activity have been used different methods, such as markers placed on the body (IMUs placed in different parts of the body) and systems without markers in the body with infrared sensors and inertial tools [6]. The methods to capture crawling movements of infants are limited, but they have been effective to record the kinematics of the extremities of infants [7–9].


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Other studies covered baby position in dorsal and ulnar movements. The crawling movements are captured with a system based in markers [10–12]. Recent studies cover the kinematics of baby movements without markers, through minimally invasive systems using sensors and cameras. These systems have shown to be more friendly and flexible [13, 14].

In this context, in recent years virtual reality has been involved in the development of new applications tested in motor rehabilitation. Virtual reality participates in studies with other technologies [15–18]. While devices with better technology are used, it will increase the efficiency of therapies and improve the immersion level experienced by the user. These kind of systems have become very popular, especially in the treatment of children with disabilities [17–21]. In many systems, a good response is obtained in the use of 2D and 3D mapping as scanning method high precision, creating a very reliable tracking method [22–24].

## 2 Structure of the System

A virtual and novel system is developed to enhance the crawling skill in infants, through the baby interaction with virtual objects, which move on a projection on the floor.

The system includes bright 3D environments, which the infants can interact in real time. To capture baby attention has been designed a friendly and attractive objects for the interface.

The interaction is due to mapping 2D, where infrared sensors made the infant movement scanning on the projection. In addition, the environment is harmonized with melodies and sounds feedback. Then the block diagram of the system is presented in Fig. 1.

## 3 System Development

This section describes the development of the system. The operation system diagram is shown in Fig. 2.

Next, the stages considered in the development of augmented reality system are presented:

**Data Acquisition**
The first stage corresponds to the system inputs. The infant movements performed while moving his body crawling on the projection is collected. This is done by using mapping 2D infrared sensor of Magixbox, which returns this information to the virtual interface.

**Scripts Development**
The flowchart in Fig. 3 explains the operation of the applications, according to the activities programmed in C#. At the time the application runs, the initialization of variables is made. When the infant is over the projection can interact with virtual

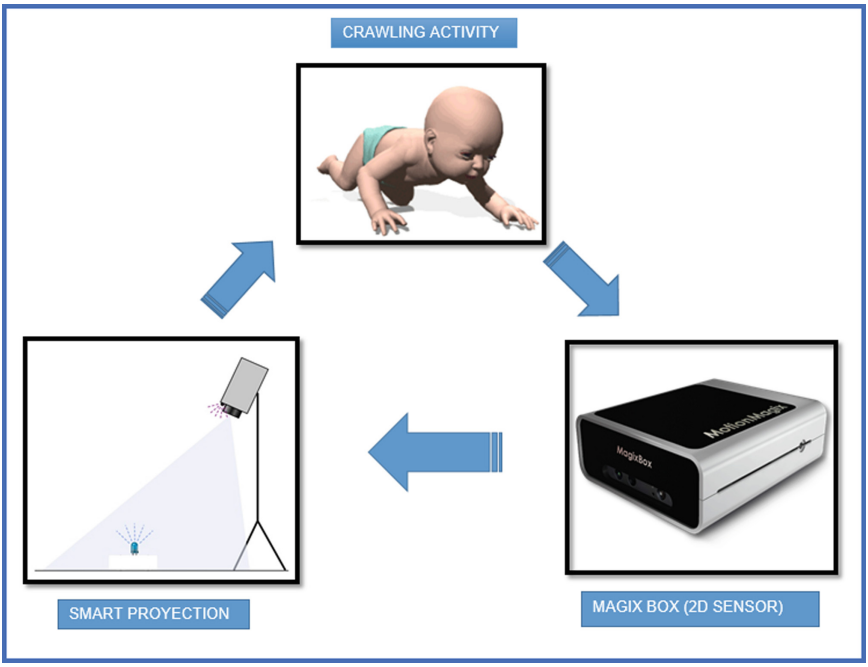


**Fig. 1.** System structure block diagram.

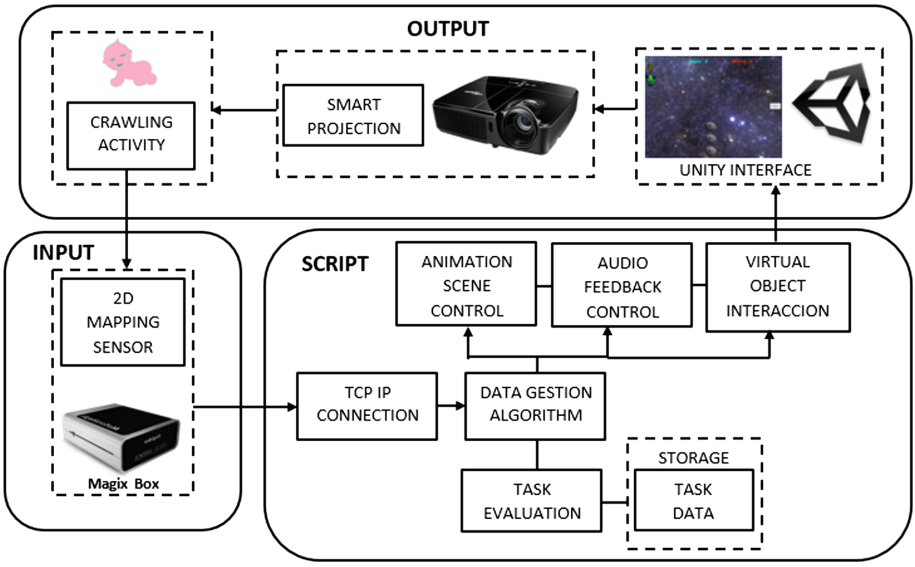


**Fig. 2.** Operating System Diagram.

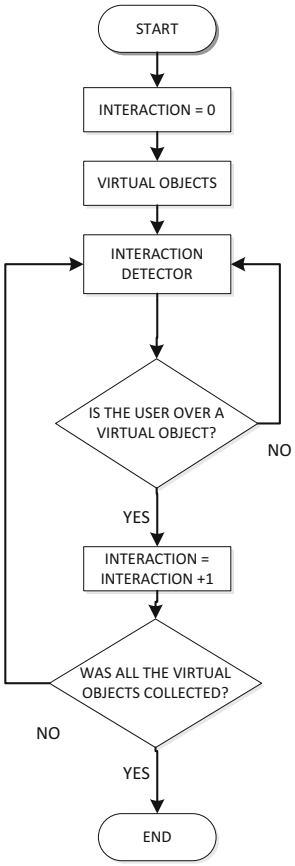


**Fig. 3.** Scripts Development Flowchart.

objects that are presented. A saving system where the user must go crawling over each object to increase the score is presented. In addition, it uses another virtual object that guides the baby towards the next target.

**Environments Design**

Animations of the environments are created in the Unity 3D graphic engine. The environments are designed with the topic "Sidereal Space", where stars and rockets are objects that the user will have to reach. These virtual environments will be projected on the floor in a designated work area. The user can interact with objects displayed in real time, in Fig. 4 environments created are presented.

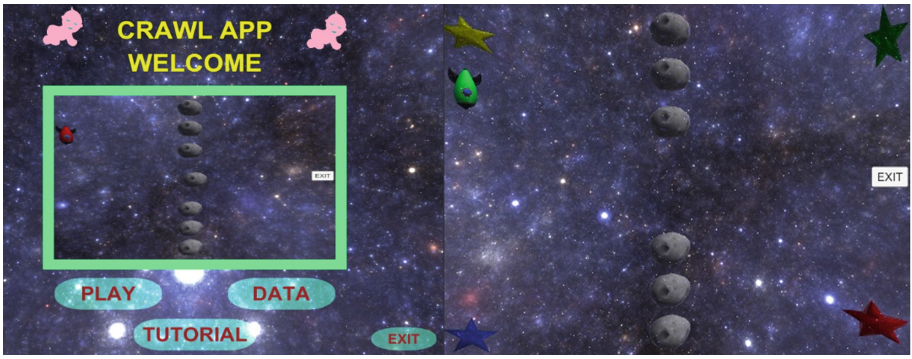


**Fig. 4.** Virtual Environment Design.

## 4 Test and Results

**Test**

The tests to be performed are aimed at determining the functionality of the system. A doll is used to perform the crawling activities on the virtual stage projected on the floor.

Several experiments are tested placing the projector in different angles. This proof determine the real time response of the interaction between the doll and the virtual objects. In addition, it verifies the functionality of the application. The tests follow the sequence in Fig. 5.


**Fig. 5.** Application Operation

**Results**

The results presented in Table 1 correspond to the tests performed by the doll in the crawling position in three different projection angles. According to the results projection around a 90° angle, it has a higher percentage of effectiveness (95%).

**Table 1.** Results of three projection angles

| Angle projector/sensor | Number of tests | Number of right answers | Percentage of effectiveness |
|---|---|---|---|
| 135° | 20 | 16 | 80 |
| 112° | 20 | 17 | 85 |
| 90° | 20 | 19 | 95 |

Thus the effectiveness of a body (doll) to collect virtual objects in real time and sensitivity are in interaction with each object is also verified. An indicator is provided with a counter, which the number of items collected is recorded.

This test verified that the system has an optimum speed of response and acceptable sensitivity to run in real time. The speed with flowing virtual environment is 60 fps.

## 5 Conclusions and Future Works

The virtual system is reliable and has very attractive activity that motivates children as a crawling exercise alternative. Preliminary tests indicate that a projection in 90° has 95% of matching response and a speed of 60 fps.

As future work, the system will be implemented in dedicated therapies to improve infants in the crawling activity. A complete, attractive and intelligent system was developed, which is able to assess the level of progress that has a user in the capabilities development.

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