Jecripe: How a Serious Game Project encouraged Studies in Different Computer Science Areas

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Abstract—Serious game projects require multidisciplinary professionals, including programmers, designers and game designers. In games for health, one more type of professional must be included which is the one with health knowledge. The Jecripe Project has the aim of developing serious games for people with special needs. The professionals from health science are speech therapists and more professionals have the intention to be part of the mentioned project. However, this work presents how a serious game project motivated studies in different Computer Science research areas. We describe the three main studies in the Jecripe Project, each of one in a different area: Computer Vision, Data Mining and Human-Computer Interaction. The intention of the continuation in the project is to perform more studies including the integration of natural user interfaces in games for people with special needs.

I. INTRODUCTION

The Jecripe Project aims to develop serious games, ludic systems and applications for people with special needs and make them freely available for downloads. We first started with the development of the Jecripe game, a game for children with Down syndrome in pre-school age. The contribution of this work is the description of how a serious game project (Jecripe Project) motivated studies in different Computer Science research areas. We describe the three main studies in the Jecripe Project, each of one in a different area: Computer Vision, Data Mining and Human-Computer Interaction. The intention of the continuation in the project is to perform more studies including the integration of natural user interfaces in games for people with special needs.

The inspiration for our proposal started when one of speech therapists of our project, being a speech therapist, tried to stimulate children with Down syndrome by observing their interaction with games. Those games were not developed for people with Down syndrome, nor did the authors know of any public or commercial game developed for children between 3 to 7 years old with Down syndrome. Aiming to design a game to fit this niche, the Jecripe game was created.

The activities proposed in the Jecripe game were elaborated according to the special needs of children with Down syndrome but Jecripe can also be used by children without special needs. Another characteristic of the Jecripe game was the introduction of virtual characters with Down syndrome, so that children can identify themselves with the game. None of such characters were found in any game known. The Jecripe game can be freely downloaded from the official website and it is available in Portuguese, English, Spanish, German and Turkish. The contribution of this paper is a detailed explanation on how the Jecripe Project encouraged studies in different computer science areas.

This paper is organized as follows. In Section II, we describe the first serious game developed in the Jecripe Project is described. Section III presents how the Jecripe Project motivated studies in different Computer Science research areas. Finally, in Section IV we expose the final considerations and future directions.

II. THE JECRIPE GAME

Much attention has been directed toward identifying special needs associated with Down syndrome in speech therapy and psychology research. Researchers have been able to show patterns of behavioral characteristics including strengths in the areas of social functioning and weaknesses in such areas as language, short-term memory, imitation, perception, visual-motor skills and other cognitive functions [1]. This knowledge, combined with studies demonstrating effective intervention strategies, contributes in the advance of computer based cognitive interventions for the development of people with Down syndrome.

Based on studies and observations, some of the authors of this work had developed Jecripe, which is designed for children with Down Syndrome. Jecripe is a pool of different scenarios, each one prepared for specific requirements, but all of them unified by a main character who also has Down syndrome.

Concepts of such interdisciplinary effort were incorporated during Jecripe original design [2]. The Jecripe game is the first game developed in the Jecripe Project. In this first game, three cognitive abilities were selected to be stimulated: imitation, perception, fine motor skills and hand-eye coordination. Each of the selected cognitive abilities inspired the development of a virtual environment. This section presents Jecripe’s scenarios, the game that aims to stimulate preschool children with Down syndrome.

A. Imitation and the music house

The development of imitation skills is highly associated with language development. Studies have shown that to learn
language, children must be able to imitate. This ability has an important impact in the development of socialization skills, because through imitation, children learn how to behave, cooperate and react [3].

Children with Down syndrome show significant deficits in imitation skills when compared with those with typical development [4], [5]. Their imitations are poorer and more restricted. However, they show better performance in imitation than in expressive verbal language tasks [6], [7].

The finding that children with Down syndrome can accurately reproduce rhythmic stimulus [8] shows that allying music to cognitive interventions can be a rewarding form of stimulation. The rhythms and repetitiveness of music help children with Down syndrome to remember something more easily and music fits perfectly in imitation tasks.

The findings mentioned in this section inspired the design of the imitation tasks created for Jecripe in a virtual scenario named The Music House. In this house the game demands the imitation of simple movements of the body, accompanied by singing interactive songs.

Starting this scenario, aiming to stimulate fine motor skills and hand-eye coordination ability, the player is induced to click twice on the doorbell, by an instruction voice. Once the task is completed, the player can then see the front of the house with six windows. Each window is associated with a different simple choreography and correspondent song.

Next, the user chooses a window using a single click. After that, the window opens and a character appears and starts to dance so that the player is induced to dance with him (Figure 1). After the song is played, the window is closed and the user is conducted to his or her original position, in front of the house. The player can dance each song as many times as he/she wishes, until all the dancing windows are visited.

B. Perception and the bubble house

According to Schopler et al. [3], auditory and visual perception, serve as the basis for the choice and organization of stimuli. The speed of sensory discrimination is affected in children with Down syndrome. According to López and Nuevas [6], those children tend to focus more on details than on the visual stimuli and this impairs their performance in visual discrimination tasks. They need longer periods of time to react to stimuli and present a greater frequency of wrong answers as a response to perceptual tasks [9].

Considering the importance of the exposition of those children during pre-scholar age to auditory and visual stimuli to overcome limitations in perceptual processes, a scenario was created in Jecripe, named The Bubble House (Figure 2), that exercises the well-functioning of visual and auditory modalities, guided by different sounds. During this scenario, the player uses the mouse only by moving it (without clicking). During all stages, the game constantly rewards each accomplished sub-task with positive reinforcement sentences.

The Bubble House scenario contains three stages designed to stimulate the perception ability. During the first stage, an instructor voice guides the player in order to prepare a bubbles recipe, the player has to mix a set of ingredients correctly and move them into a recipient. The first ingredient is a water bottle, followed by a soap bottle and a cover cap.

During a second stage an instruction voice induces the player to pop floating bubbles. Some of those bubbles have colored toys inside them. When a bubble is popped, the respective toy falls down to the ground. The condition to complete this stage is to pop all the bubbles that contains a colored toy. This stage was developed in order to stimulate fine motor skills and hand-eye coordination ability.

The third stage of this scenario starts and the player is invited by the instruction voice to put the colored toys inside boxes according to their matching colors. Once all the toys are placed in their respective boxes, a voice greets the user.

C. Fine motor skills and hand-eye coordination and the day care center

Autonomy and independence in activities of daily living depend heavily in the development of fine motor skills [3]. Hypotonic muscles and alterations in the articulations contribute to reduce the strength of manual grasping of children with Down syndrome, making it difficult to manipulate objects. They also have difficulties in integrating visual and proprioceptive information, consequently, hand-eye coordination is
impaired. Later, the development of writing skills relies in the competence of these functions.

The Day Care Center scenario was designed specifically for the stimulation of fine motor skills and hand-eye coordination together with receptive and expressive verbal language (although it is also exercised indirectly in the Bubble House scenario). Playing with the Day Care Center the child manipulates the mouse to drag-and-drop objects to deliver personal objects to a baby character (Figure 3).

Inside the Day Care Center, there are four objects placed on top of the shelves and a baby character. He does not know how to talk, but continuously asks for what he wants by pointing at the desired object. The baby also turns his body and face directly to the object, indicating his wish to catch the desired object. The instructor’s voice speaks reassuring his wish.

When a player clicks on an object which is not the one that baby wishes, he manifests dissatisfaction. Then, the instructional voice indicates the desired object and the baby faces that specific object again until the user grants his wish.

Once the correct object is clicked, it moves with the mouse cursor while the mouse is being pressed so that the player can drag the object closer to the baby. When the mouse button is released, the position of the dropped object is checked. If the object is released in any other place, but not closer to the baby’s body region, the object is moved back to the original place on top of the shelf. After all the objects have been delivered to the baby, he starts clapping his hands and a success audio clip is played telling about the end of the activity.

III. JECRPE IN COMPUTER SCIENCE

Since 2009, the Jecripe Project motivated studies in different Computer Science research areas. In 2009, when the Jecripe Project started with the development of the first game, a starting study in the Computer Vision area was presented. In [10], it was shown the intention to work with Natural User Interfaces and the integration of this paradigm in the Jecripe game. Further studies were done in Computer Vision and the M5AIE method [11], [12] have been developed.

As a direct consequence of the studies in Computer Vision, more work have been done in Data Mining. In 2013, we had performed experiments with classification algorithms to report which would be the best classifier using the M5AIE method. The experiments with classifiers were presented in [13]. All the studies in Computer Vision and Data Mining areas were inspired in the Music House of the Jecripe game.

The Jecripe game was introduced in 2010 [2] and it motivated further studies in the Human-Computer Interaction research area. A Semiotic Inspection was performed and described in [14] to evaluate the communicability of the game. The following sections describe each of Computer Science research areas involved the the Jecripe Project.

A. Computer Vision – The M5AIE Method

As it was described, the Music House is an environment of the Jecripe game whose main goal is to stimulate the imitation cognitive ability. In the Music House, the main character sings and dances musics and the player should imitate that character. This ludic activity has to be supervised by an adult who is supposed to judge if the movements of the player were performed correctly or not. However, the intention of integrating Natural User Interface to our game motivated the development of the M5AIE method [12]. The M5AIE method makes body part detection and labeling.

The M5AIE method aggregates different concepts; some of them were not originally developed for detecting, tracking, and pose classification. After the alignment of the RGB and depth information of a given frame, we use the Minimum Background Subtraction algorithm [15] to address most of the unnecessary information in the frame (Section III-A1). In turn, the area of the person facing the sensor is replaced by the few pixels that define its discrete medial axis transformation (Section III-A2). The detection of body part candidates begins by building a graph in which each pixel of the medial axis is seen as a vertex that is connected to its neighbors by weighted edges; each weight is given by the Euclidean distance between a pair of pixels (Section III-A3). Using this graph, body part candidates are detected through the AGEX points detection method (Section III-A4). A labeling step is performed to relate AGEX points to their respective body parts (Section III-A5). When labeling fails, the information computed in the previous frame is used in combination with the ASIFT method for tracking the body parts into the current frame (Section III-A6). Pose classification is performed in the last stage of our method (Section III-B).

1) Minimum Background Subtraction Algorithm: The Minimum Background Subtraction algorithm is composed of training and subtraction stages. During the training stage, the approach limits the background values regarding the following assumptions: indoor environment, static background, and static position and orientation of the sensor. The algorithm is presented in [15]. We have chosen to use this background subtraction algorithm because it had the best results in previous experiments [16].

2) Discrete Medial Axis Through Distance Transformation: The 2D medial axis transform constitutes finding the centers of the maximum disks that can fit inside of an object [17]. We use such a structure to reduce the number of pixels that are to be considered as vertices in the graph computation (Section III-A3). By doing so, we reduce the processing
overload of the next stages of our method. We have performed medial axis extraction by computing the distance transform of the binary image that results from the background subtraction.

3) Graph Construction Based on Depth Image: We use image pixel coordinates to build a graph in linear time, as implemented in Schwarz et al. [18]. In such a case, two vertices are considered to be neighbors if the corresponding pixels are separated by a maximum distance threshold \( \delta \). We follow Plagemann et al.’s strategy [19] to connect two vertices and Schwarz et al.’s scheme to weight the edges with the Euclidean distance of the imaged surface points related to the vertices. However, we build the graph with medial axis pixels only, while previous works use the whole shape of the user. As a result, we get an optimized graph.

4) Accumulative Geodesic Extrema Points: Accumulative Geodesic Extrema Points, known as AGEX points, are selected while considering the distances of the points according to the edges that connect the vertices in the graph \( G_t \) [19]. This method maximizes the distances of the points using the Dijkstra [20] algorithm. A detailed description of AGEX is presented in [19].

5) Body Part Labeling: The initialization step for body part labeling comprises a person facing the camera for a few seconds and taking a snapshot on a T-pose. Because the first AGEX point \((AGEX_1)\) is the centroid, we can define the lower and upper parts of the body and separate the other points (from \(AGEX_2\) to \(AGEX_0\)) according to their coordinate values.

6) ASIFT-Based Body Parts Tracking : In our tracking strategy, ASIFT is used to identify the features in the frame \( t \) that are related to the AGEX points identified in frame \( t-1 \). However, ASIFT (more details in [21]) cannot be used directly in tracking due to some practical issues: (i) the time execution increases as the input images become larger; (ii) in the case of background segmented images, ASIFT detects too many features in the border of the foreground region; (iii) there is not necessarily a matching feature for every pixel from one image to another; and (iv) ASIFT can match two features whose positions are far away from an expected conservative maximum distance. We addressed these problems using the following heuristics:

- Use of tiny images instead of complete frames;
- Blurring the background of sub-images;
- Searching in a region instead of searching for coordinates only; and
- Body-parts position estimation.

In our framework, the acquisition of the color and the depth images is performed by the same device (a Kinect), and the RGB-D image alignment is performed by Kinect SDK. However, due to the asynchronous nature of the image sensors, the final aligned RGB-D image may be ill-formed. As a result, background color pixels can be incorrectly mapped to foreground regions. To make the proposed matching procedure suitable for tracking, we found four major situations to be handled: (i) the matched ASIFT feature and the point estimated with the uniform linear motion equation correspond to well-mapped background pixels; (ii) the matched ASIFT feature resides in the well-mapped background while the estimated point is part of the users body; (iii) the matched ASIFT feature belongs to the human body, and the estimated point is part of the background; and (iv) both the matched ASIFT feature and the estimated point correspond to the actual body. Due to space restrictions, this paper does not include a discussion about how to handle each situation.

A detailed description of the experiments with the M5AIE method was presented in [12]. In this work, we describe only the resume of the experiments in [12]. As mentioned before, the collected sequences of human poses were inspired in the Jecripe game’s Music House dancing movements. The poses were: T-pose, dancing (left hand on hip and right hand on head), playing guitar, playing flute and playing drums. Two other movements, which were not related to the game, were also included: punching and kicking. We used three different volunteers in our experiments: A, B and C. For each user, we collected a different number of sequences. Volunteer A is male, 1.76 meters tall, and has dark hair. We collected 17 sequences with all of the classes. Volunteer B is male, 1.90 meters tall and has blond hair and made 14 different sequences in four classes, all of them without self-occlusion. All of the possible poses for each of the four classes were collected. Volunteer C is female, 1.66 meters tall and has dark hair. Similar to Volunteer B, we collected sequences of four different classes with Volunteer C. Additionally, no problem was detected during the collection of the poses, which shows that the M5AIE method works well in sequences that do not have self-occlusions. We collected 13 sequences with Volunteer C because we wanted to test fewer training tuples with the pose kick + punch (A).

We observed that the M5AIE method had problems with poses that had self-occlusions. The problems were detected in the playing guitar and playing drums poses. This problem detection was crucial for the collection of the other users sequences; as a result, we avoided collecting these poses. However, we kept the results to make the tuples and test the classification algorithms. In only one sequence, the tracking method had problems that were caused by the movement velocity, but the pose classification was not affected.

B. Data Mining – Pose Classification

Classification techniques were used in this study to identify categorical labels such as “Pose A” and “Pose B” for the current subject, according to the position of each of the body parts that are detected or tracked in a given image of the sequence.

The human pose classification was performed using three different algorithms: the C4.5 Gain Ratio Decision Tree [22], the Naive Bayes classifier [23] and the K-Nearest Neighbor (KNN) classifier [24]. These algorithms were selected due to their low computational load and simplicity, which makes them suitable for real-time applications.

1) C4.5 Gain Ratio Decision Tree: Decision trees follow the “divide and conquer” approach. According to Amor et al. [25], the decision tree structure is composed of the following elements: (i) decision node, which specifies a test attribute that is responsible for the comparison of an attribute value with a constant; (ii) an edge that is one of the possible attribute values (the test attribute is placed here); and (iii) leaf nodes that give the classification to which the object belongs.
Decision trees have two stages: building the tree and the classification itself. Building the tree constitutes selecting the test value for each decision node and the classification labels of each leaf. Decision trees are built based on a given training set. The classification stage is made starting from the root of the decision tree. To go down the tree, tests are made to achieve one of the leaf nodes.

Many algorithms were developed for the construction of decision trees for the classification task. In the experiments, the considered decision tree was the C4.5 Gain Ratio Decision Tree algorithm developed by Quinlan [22]. The C4.5 Gain Ratio Decision Tree selects the attribute that has the largest number of possible values to be assumed as the current node in the tree construction. This criterion is an extension to information gain. However, the Gain Ratio applies a normalization to information gain. Then, the selection of an attribute to be the current node in the tree is defined on the largest gain ratio value. The Gain Ratio value is obtained by the information gain and the normalization of the probability of each of the attribute values.

2) Naïve Bayes Classifier: Naïve Bayes makes a strong independence relation in which the features are independent in the context of a session class [25], [23]. The Naïve Bayesian classifier works, basically, as follows: (i) the training set is composed of tuples, and these tuples are attribute values in a predefined order; (ii) for each class, a conditional probability can be calculated based on the used training set; and (iii) the likelihood of a testing tuple is defined based on the calculated conditional probabilities of each class.

The main difference between the two mentioned classifiers is that while C4.5 is a decision tree classifier, the Naïve Bayes is based on the Bayes rule of conditional probabilities. In decision trees, the attributes are tested, and the final classifications are at the leaves. In this approach, the attributes have a high level of dependency on each other. However, the Naïve Bayes classifier evaluates each attribute individually, considering them to be independent.

3) K-Nearest Neighbor Classifier: In 1967, Cover and Hart [24] introduced the k-Nearest Neighbor as a pattern classifier. A training set is built by tuples and a tuple \( X \), whose class is unknown, is then tested. The tuple \( X \) is compared with each of the training tuples. The \( k \) closest tuples to \( X \) are considered to predict its class. “Closeness” is considered a distance metric, and it can be calculated, for example, with the Manhattan, Chebyshev or Euclidean distance. The unknown class of \( X \) is assigned to the most common class among its \( k \) nearest neighbors.

4) Bounding Box and Grid: In this work, the algorithms receive as input the labels and the locations of the body parts according to an \( N \times N \) grid that is defined inside the bounding box that contains the whole body of the imaged subject. Fig. 4 shows the grid squares with \( N = 8 \). A bounding box was used to identify the cell number of the body parts. The bounding box provides the relative positions according to the detected human body. This approach makes it possible to identify the cell number of the body parts, independently of their occupied positions in the whole segmented image.

The considered classification algorithms (C4.5, Naïve Bayes and KNN) require the execution of a training stage to build a model to be used during the classification of the poses. In our work, the dataset is used both for training and testing. The class of each tuple comprises the cell-coordinates in the grid that body parts assume at each image in a sequence. The pose classification of each training tuple was made manually in each frame. In the classification procedure, a tuple constitutes a sequence in which the cell position of every individual body part is described in the same order as the order that appears in the attributes definition.

The dataset that was used for both the training and testing comprises the grid-coordinates that body parts assume at each frame of a set of image sequences that were produced for this work and the manual classification of the pose in each frame. In [13], we show how we varied the number of cells of the grid in each frame. The resume of the experiments of [13] is described as follows: we used three volunteers that had very different biotypes to collect the pose sequences with variations in the numbers of images and poses. In addition to the different classification algorithms, we tested three types of distances: Manhattan, Chebyshev and Euclidean. In all the experiments with the KNN Classifier, as the \( k \) value increased, the percentage of correctly classified instances decreased. This happens because if we consider a high number of nearest points, we start to observe very different points that could be far away from the considered point and they affect the final result. We consider KNN with \( k = 1 \) and the Manhattan distance as the winner because it provided the best results in all of the experiments. We believe that the coordinates of the five main body parts can be normalized in the bounding box because, in our experiments, as long as we increased the division of the used grid (8, 16, 32 and 64), the results became better. However, we also believe that there is a limit when dividing the grid. Further experiments should be performed to find the value for which the division does not make sense anymore. Further experiments should be performed to prove that normalized coordinates could be a good choice in the usage of a bounding box for cell definition.

C. Human Computer Interaction – Communicability

The Semiotic Inspection Method (SIM) has been proposed within the Semiotic Engineering theoretical framework [26]. Semiotic Engineering perceives HCI as a designer to user metacommunication. It is a twofold communicative process,
because the designer to user communication is achieved through user-system communication. Therefore the primary purpose of SIM is to evaluate the communicability of interactive computer artifacts. As is typical of HCI inspection methods, SIM does not require an observation of users interacting with the system. Rather, the method helps inspectors anticipate the kinds of consequences that design choices may bring about when users interact with the system. It can be carried out by a single inspector or a group of inspectors [27].

As described by de Souza et al. [28] SIM has a technical and a scientific application. Technical application of SIM focuses on how a method can improve and inform interaction design in the context of a specific system development; whereas scientific application focuses on how a method can broaden the knowledge of Human Computer Interaction (HCI). Hereby we describe the SIM method according to the steps described in [28], [29] and [30]. SIM is an interpretive method through which the evaluator analyzes the message being transmitted by signs at each level: metalinguistic, static and dynamic.

Metalinguistic signs are signs that refer to other interface signs. They are instructions, tips, online help, error and informative messages, warnings and system documentation. They are signs that the designer uses to explicitly communicate to users about the meanings encoded in the systems and how they can be used. Static signs express and mean the systems state, they are motionless and persistent when no interaction is taking place. They can be perceived (and interpreted) in snapshots of the systems interface before or after interaction occurs. For instance, buttons, text areas and check boxes at a given moment. Dynamic signs express and mean the system behavior. Their representations unfold and are transformed into responses to an interactive turn. For example, if we click on the search button the behavior will present the results of a search. This behavior is a dynamic sign [28].

SIM is applied in five main steps:

1) The analysis of metalinguistic signs;
2) The analysis of static signs;
3) The analysis of dynamic signs;
4) A comparison of the designers metacommunication message generated in the previous steps; and
5) A final evaluation of the inspected system’s communicability.

We have performed the Semiotic Inspection Method to the Jecripe game to evaluate the communicability of our application. In this work, we shortly describe how was the application of SIM. More details about SIM on the Jecripe game are in [14].

In our scenario, a child with Down syndrome is the central character and she was induced to use our game. The selected cognitive abilities were stimulated through our application and the goal of the inspection was evaluate how feedback is communicated to Jecripe’s players.

As a template result we can summarize the analysis of metalinguistic signs in the following messages, where “we” means “we, the designers” and “you” means “you, user, or in this case, the player”: a) You can hear the audio instructions provided to you to know what to do. In the Day Care Center you can hear and see Samuca’s movements and decide what you should do. b) You can hear instructions again if you stay for 5 seconds without interacting correctly with the game. c) In the Day Care Center you can perceive the feedback (positive or negative) about your action through audio and movements emitted by the Samuca character. d) In the Bubble house you can perceive the feedback about your positive action through audio messages such as: “Look, you hit the bubble”. e) In the Music house you can perceive the feedback only at the end of activity. f) You can see which houses are available to play through illumination over them. g) Before you leave the game you receive a feedback about which houses you have played. In case you have not played in any of the houses, you will hear a message inviting you to go back and play. h) If you want to obtain more information about the game functionalities, you should ask for the adult responsible which is following you.

During the analysis of the static signs, important signs were identified with regard to the feedback messages: a) We provide a playful introductory environment and you can notice that you are in a room with a door a window and a table. On the table there is a map and a factory (Figure 5). b) We provide a playful interactive environment called the Bubble House and you can notice that you are in a room with a water bottle, a soap bottle, a cover cap, floating bubbles, colored toys and colored boxes. (Figure 2). c) We provide a ludic interactive environment called the Day care Center and you can notice that you are in room with a chair, a baby (called Samuca with Down syndrome) sitting on the chair, four objects (a rattle, a soup plate, a pacifier and a baby bottle) on four shelves (Figure 3). d) We provide a ludic interactive environment called the Musics’ House and you can notice that you are outside a house with six windows and a character (called Beitinho with Down syndrome) sitting on the chair, four objects (a rattle, a soap plate, a pacifier and a baby bottle) on four shelves. e) We provide audio instructions adapted to activities of each interactive environment. f) We provide a mouse pointer using a child’s hand metaphor with Down syndrome appearance. g) We consider that you will be able to infer that the lighted houses (as shown in Figure 6) can be selected by clicking on it. h) We consider that you will be able to infer the following mouse interaction forms: just moving the mouse in the Bubble House and dragging-and-dropping the mouse in the Day Care Center. i) In the Music House, we expected that you will be able to infer that you should follow Betinho’s movements.

During the analysis of the dynamic signs, the essence of what Jecripe designers intend to communicate to the players can be understood as the system behavior. Then, the feedback system behavior can be summarized in: a) We use various metaphors of playful environments to determine the activities and interactions you may have with the game. b) We consider that you have some previous knowledge about computer-based usage. c) We expect you start playing immediately after listening the first instruction. d) During the game interactions in the Day Care Center and in the Bubble House you can listen to messages related to the results of your actions. e) During the game interactions you can see information (e.g. Samuca baby’s animations) related to the results of your actions. f) While performing mouse-based interactions you can visually infer when the mouse is pressed and released through the hand
animations (e.g. metaphor for the mouse pointer).

In the collate and compare stage, we concluded that the metalinguistic signs are important keys for the success of Jecripe game once they assist the players actions continuously over time. The metalinguistic signs motivate players in this game by providing them with the necessary information to better understand what they should do.

Also we noticed that the player can change the order to visit the selected activities independently of its difficulty level. We also observed that different kinds of informative feedbacks were being used along the houses. It is important to remember here that the inspection analysis was mainly focused on the feedback aspects of Jecripe interface. Others signs, for instance, those related to the interface navigation, could also be analyzed in further evaluation.

The resume of the comparison of the designers metacom- munication message generated in the previous steps and the final evaluation of the inspected system’s communicability, according to each of the playful environments, are described in the following:

- The Musics House: the player can not imitate all the movements suggested by the character because the amount and complexity of these movements are very hard for children with disabilities. Also, the lyrics of the songs do not induce the players to dance correctly and one as a consequence, sometimes, the player would stand still.

- Bubble House: in this house, the user does not have to make a mouse click to execute the activities but the observed player use to click because she knows how that device works.

- Day Care Center: it was possible to observe that the knowledge of how the mouse works was used very well in the drag-and-drop activity.

Besides these feedbacks, an inclusive school has provided the use of Jecripe and observed that the application facilitated socialization between the students with Down syndrome and the others without special needs. Also, the game promoted positive socialization experiences between children with other kinds of special needs. A child with autism had fun with the other children by playing with Jecripe.

By performing the inspection evaluation it was possible to observe mainly positive aspects of the Jecripe interface. However with additional observation of game usage, it was possible to increase the evaluation. Looking for improvements in the learning process, the Jecripe game could provide the possibility of controlling the access order of each house as well as to have a major goal guiding the interactions through the houses. Of course such suggestions should be discussed and validated with the specialized multidisciplinary group (therapists, educators, children’s parents) involved in the Jecripe development process.

IV. FINAL CONSIDERATIONS AND FUTURE DIRECTIONS

In this work, we presented the Jecripe Project and the first game of this project for children with Down syndrome in prescholar age. The Jecripe game was especially developed for these kind of users but children that do not have special needs can play with Jecripe too.

We described the three environments of the Jecripe game and each of them was created inspired on selected cognitive abilities to be stimulated. The imitation cognitive ability motivated the possibility of integration of Natural User Interfaces in our game [10]. Further studies inspired research in Computer Vision and Data Mining. In Computer Vision, we performed experiments to select a background subtraction algorithm [16]. We also developed the M5AIE method for body part detection, tracking and labeling [11], [12]. As a direct consequence of the Computer Vision studies, we had performed experiments in Data Mining with different classification algorithms [13]. Additionally, in the classification experiments, we concluded that there is much more studies to be done in this direction.

The Human-Computer Interaction area is also included in the Jecripe Project. We applied the Semiotic Inspection Method in the Jecripe game [14] to evaluate the communicability of our application to the users. There are ongoing studies in this area that includes: Universal Design [31], Participatory Design [32] and Game Design [33]. We intend to integrate all of the mentioned design concepts to create a method whose main goal is to develop ludic universal applications using Natural User
Interfaces. We intend to continue developing universal games considering different special needs exploring new interaction paradigms, according to the progress of our work.

In this paper, we did not provide any report on the application of the game with real end-users or the evaluation of the efficacy because we still did not done detailed studies of this type. However, we intend to make experiments with end-users with Down syndrome to evaluate its efficacy and measure how good is our the game on stimulating children with special needs. In the end of our experiments, we intend to report on application and evaluation results.

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REFERENCES


