Motivation Based difficulty adaptation for therapeutic games

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***Abstract*—A post-stroke rehabilitation based on therapeutic serious game can be a useful approach to increase rehabilitation volume by maintaining patients' motivation and engagement. In particular, a dynamic difficulty adaptation technique of therapeutic tasks allows increasing patients' motivation by adapting the game difficulty to the patients' capabilities. This paper presents a difficulty adaptation technique dedicated to a family of therapeutic games for upper limb rehabilitation. The proposed technique provides a generic real-time adaptation module to dynamically adjust the game difficulty to each patient according to his profile and observed performances. A pre-pilot experiment is presented to demonstrate how this technique has been implemented and could be integrated to post-stroke therapeutic games.**

***Keywords*-Game Difficulty Adaptation; Post-Stroke Rehabilitation; Therapeutic Game;**

I. INTRODUCTION

"Serious game for health" or "Game for health" is considered as a promising research domain both for health and ICT sector. Actually, health application domains are varied and concern different end users such as: doctors, students, patients, researchers, the general public, etc. A game for health can be useful in diagnostics, prevention, advertising, training, fitness, rehabilitation, relaxation, etc. To date, there are different research and industrial activities that have a great interest in health games. Their purpose can be focused on using the serious game as: a functional training or rehabilitation tool (Mojos [22]), a prevention tool (Science Pirate [28]), a relaxation way (MindHabits [23]), a training tool for students in medicine (Pulse [27]) and/or a tool for understanding chronic illness (l'affaire Birman [2])

In our research activity we focus on health games dedicated to post-stroke rehabilitation. A stroke is a medical emergency that can cause permanent cognitive and motor impairments. It can affect comprehension, memory, visual recognition, attention and the ability to move one or more limbs on one side of the body. The specific abilities that can be affected by stroke depend on the location, type and size of the lesion. Each patient is then characterized by a specific combination of deficits.

Different research activities deal with rehabilitation strategies after stroke. These strategies are often heterogeneous and depend on the therapists practices. We can mention for instance the use of constraint-induced movement therapy, EMG biofeedback, robotic aid, mirror therapy and virtual reality or serious gaming therapy (for more information on this topic see e.g. [25]). Each strategy has special advantages in one or more particular stroke recovery and none of them is considered as a standard.

In addition, stroke rehabilitation programs are strongly different as they are personalized to patients in order to regain as much their cognitive and motor function as possible. Furthermore, during the rehabilitation process patients often recover slowly and hardly some of their motor abilities. With repeated therapeutic activities, patients often become tired and frustrated. Therefore patients' motivation has often to be supported during their rehabilitation sessions. As a matter of fact, the therapist had to continuously support the patient by encouraging him and adapting the rehabilitation exercises to his ongoing condition.

Most rehabilitation techniques are founded over the principles of motor learning and skill acquisition established for the healthy nervous system. These studies suggest that intensive training (many repetitions) while giving feedbacks [4] and motivating the patients can have an important impact on the patients' skills recover [18].

The potential benefit of training based on virtual reality or serious game strategies consists in providing an environment in which the training intensity, duration and frequency can be manipulated and enhanced. This manipulation could be used in order to motivate the patient by creating a personalized motor learning paradigm [17]. For instance, integrating gaming features in virtual environments for rehabilitation could enhance patient motivation [26] which, in turn, is a key recovery. A person who enjoys what he is doing spends more time developing his skills in a given activity.

II. MOTIVATION

Using a serious game rehabilitation strategy, the personalized motor learning can be achieved using an appropriate user-centered game design. This latter must fit accurate, personal, therapeutic objectives. The patient's performances can vary as they depend on his health condition. Thus, if the therapeutic game has not properly assessed the patients' health conditions it is highly possible that the patient will not succeed in the proposed activity, decreasing so his motivation to continue the therapy (see section 4). To avoid this effect an adaptive approach can be used.

An adaptive therapeutic game can in fact adjust its behavior basing on the patient's ongoing results. It can thus adapt dynamically the game difficulty according to the patient's capabilities assessment and motivation and not only on static user's profile. Thus, adaptation can fill the gap between patient's health condition during the game and the patient's profile assumed at the beginning of the therapy session.

In this paper, we present an adaptation technique for the upper-limb post-stroke rehabilitation based on therapeutic games. Our proposed technique results from more than a year of collaborative work with therapists and researchers from the Montpellier rehabilitation laboratory. This work allowed us to define most important elements composing the motivation model and to translate the therapeutic objectives into game goals. The proposed adaptation technique aims to increase patients' motivation by making the training a personalized experience. In fact, our purpose is to better understand practical issues related to adaptation challenges regarding the usability and effectiveness of serious game-enhanced stroke rehabilitation. The main goal is to develop a generic adaptation technique that can be useful in a family of therapeutic games.

Hence, as a first step of our study we have proposed a pilot experiment to check the effectiveness of such technique on maintaining healthy player's motivation during the game session. Once the motivation model is more stable we want to test it with stroke patients and therefore check the effectiveness of such technique on improving patients' rehabilitation volume.

The rest of this paper is organized as follows: the third section outlines the state of the art of difficulty adaptation in games. The following section aims to describe the proposed adaptation technique. In the fifth section we describe our pilot experiment. Finally, we conclude this paper by analyzing and discussing the pilot experiment results regarding our proposition in a therapeutic game context.

III. Difficulty Adaptation in Therapeutic Games

In the game context, the difficulty is often considered as the most important attribute that provide fun and enjoyment in the game. According to Malone (1987) [21] for instance, the player's engagement depends on the following four factors: (i) the difficulty to achieve the game's goals depending on players' performances (ii) the curiosity to know what action will happen during the game, (iii) fantasy or imagination by presenting objects, characters or social situations that are not real (iv) immersion (or flow) by involving the player in the game.

The difficulty of an activity (or challenge) can be defined as the degree to which the activity represents a personally demanding situation requiring a considerable amount of cognitive or physical effort. Challenging the player aims to develop his knowledge and skills [21] while increasing his engagement and motivation [24]. In addition, the adaptation of difficulty for players' activities can motivate them and avoid their non-commitment and frustration, two factors that can affect the learning curve and reduce their time for doing tasks [21].

From a game design point of view, the game difficulty level can be designed either statically or dynamically. The static approach consists in an objective determination of the difficulty level. In this case, the player can choose manually his game difficulty level or it is the game that can require him to follow a series of difficulty levels according to his performances. The dynamic approach, focuses on adapting the game to the player progresses [10], status and performance during the game experience [6]. In this context, we find works on dynamic difficulty adaptation of entertainment games (or DDA) that consider the difficulty as an heuristic function that depends on game metrics [14]. We also find techniques based on the dynamic creation of games' narratives and scenarios [31] and the creation of strategies [10] that are often based on player profile and their situations (for more information about the literature review see [13]). The player in this case fails when he reaches a point where the difficulty level is beyond his capabilities.

In fitness or sport games, the motivation is generally related to the fun aspect in the game. It consists on performing physical exercises that are attractive [16] and may easily engage people [3]. For instance, Buttussi et al, [3] propose fitness games using physiological and motion sensors. The adaptation mechanism is based on player model that contains general data about player such as his age, gender, weight, height, and his scores in prior games. The adaptation technique consists in changing the graphics and difficulty of the game according to the chosen game mode: (i) keep, to keep the player in the current heart rate range, (ii) relax, to reduce player's heart rate, and (iii) exert, to increase player's heart rate. The adaptation is performed by setting specific game parameters such as: the speed of game elements and the number of new opponents per minute.

In the context of post-stroke rehabilitation using virtual reality or serious game strategy, there is no single definition of task difficulty. Furthermore, most therapeutic games proposed in literature are based on static determination of tasks and game difficulty by therapists [1].

Heuser et al [12] suggest five therapeutic game exercises with the same graphical interfaces. Each exercise involves some difficulty levels following the main patients' motor recovery steps in therapy. The three first exercises aim to train the hand impairments basing on reaching and grasping targets. The two other levels aim to improve the arm function within the hand-eye coordination and the precision of virtual objects' placements basing on the range of virtual objects in the right holes (cylinders). The adaptation technique consists in providing real-time feedbacks to patients and therapists. Each difficulty level differs from the others by changing the color, speediness and the size of virtual objects. The player's performance depends on his finger forces, speediness and movement precision. Finally, the difficulty level is designed in a static manner. Thus, when the patient fails as the difficulty level is beyond his capabilities, the simulation stops the exercise.

Chen Y. et al [5] propose a framework for media adaptation in task-oriented neuromotor rehabilitation based on biofeedbacks [15]. This technique is based on the adaptation of players' feedbacks according to his performance. Scenery images and their clarity, sounds variety and music instruments are used to reflect the arm movement. The system suggests for each patient an adaptation technique according to the proposed functional task (reach and grasp).The adaptation technique depends on the choice of the musical instrument, tempo variation and task difficulty which is annotated by the therapist. The task difficulty has three options: making the task easier, making the task more difficult or keeping the same difficulty level. This technique uses patient profile data and variables derived from the 3D virtual space such as: the position of the player's hand, its distance from a target object, its speed etc. The decision making on adaptation uses a dynamic decision network to model the real-time relationship between the media adaptation and the patient's performance. The main idea of this work is to select in real-time the most appropriate adaptation strategy according to each patient's performance. In addition, the experiments in this work propose three adaptation factors: special accuracy, hand trajectory and hand velocity, without merging more than a factor in an adaptation scenario.

Ma et al, [20] propose an adaptive post-stroke rehabilitation system based on a virtual reality game. The therapeutic game aims to improve functional arm capabilities, visual discrimination and selective attention using three difficulty levels: beginner, intermediate and expert. The two first levels aim to improve functional arm capabilities. The fist level corresponds to the game initialization using patient profile. In the second level, the target speediness depends on the player's performance and score (success and failure rate). In the expert difficulty level, the game aims to improve visual discrimination and selective attention, which can be an important aspect to patients with hemispatial neglect. It consists in adding to the game obstacles and time constraints. The dynamic adaptation part of the system focuses on an in-game difficulty adaptation based on patient progress data. Furthermore, the system selects tasks and initially configures the difficulty level of the game using the patient model data. The system suggests a difficulty level to the patient according to his model data. This model includes mainly information about the patient's motor skills by using metrics such as standard medical motricity index [7]. The adaptation technique is based on a specification matrix that determines the relationship between the patient's profile parameters and the difficulty levels. As in previous works, the task difficulty is related to the difficulty level which is statically determined. Furthermore, the adaptation technique is based on game experience and doesn't take into account the in-game player's performances, his health conditions and motivation.

IV. Proposition

This section aims to describe the proposed adaptation technique which focuses on maintining the patient's engagement and motivation during the game session. Thus, we describe in the followings sub-sections: how the therapeutic objectives are considered in the game design, the difficulty adaptation framework, the motivation model, the abstract model for difficulty adaptation and finally the difficulty adaptation process.

In order to motivate a patient during a rehabilitation session, the variation of game themes and ambiances is required. Although the therapeutic objectives and strategies have to be maintained, I.e. they have to be independent from the actual game. Consequently, two levels have been identified: (i) an abstract movement level and (ii) an actual game level. The abstract movement level considers the mechanics of patients' movement and their relationship to therapeutic objectives; the actual game level constructs a context and meaning for the abstract level. For instance, at the abstract movement level the objective can be to reach a target point starting from a source point. This is translated differently in two games that we have developed: in one case, the objective is to scare a crow eating the crops; in the second game, the goal is to catch an animated fish [9].

In addition, from the abstract movement level point of view, the therapist's objectives are heterogeneous and can be changed during the rehabilitation session. Therapist changes for instance the objective difficulty according to the patient's performances, tiredness, health conditions and motivation.

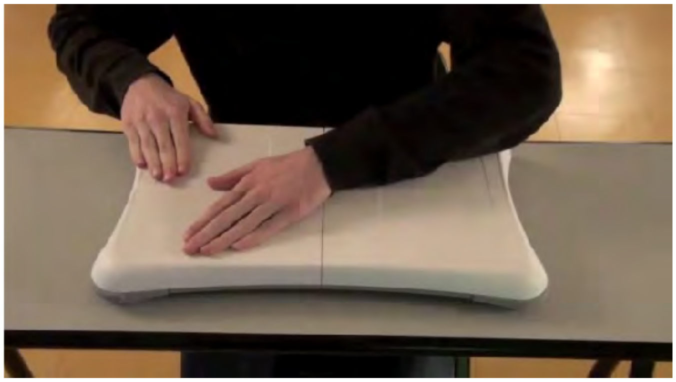

Figure 1. A player tries to stabilize the vitual ball using Wiiborad from Nintendo

Figure 2. Wii-balance game

For instance, the reaching tasks objective can be amended while changing the success or failure conditions. That is, changing the target position or introduces constraints in terms of time, movement precision, and task accuracy.
In this paper, we focus on the upper limb therapy and only therapeutic objectives related to the amplitude and range of arms are considered. In this context, all exercises, at the abstract level, follow a pattern of reaching targets placed on a 2D plane from a predefined origin. A time limit can also be introduced as an additional constraint. The movement has to be performed properly without compensation (some patients move their chest or shoulder to reach the target). This emphasizes the central role played by the therapist during the therapy session by assisting and correcting the patient's positions.

A. Wii-balance game

In order to experiment the adaptation technique we have chosen a game based on movement coordination on a 2D plane - similar to ones patients could encounter during their upper-limb rehabilitation program. The proposed balance game is based on wii-board device. However, the wii-board was used with hands and not with feet. The proposed game aims to improve player's equilibrium capabilities while achieving the game goals. It is based on a task-oriented structure in which the goal is to stabilize a ball closest to a target (a cube) within a limited time. Depending on the target's location the player finds it more or less difficult to stabilize the ball (see Figure 1 and 2).

B. General Difficulty Adaptation Framework

The rationale behind of the proposed approach is presented in Figure 3.

In practice, therapists use different strategies in order to plan patients' rehabilitation programs. These strategies are usually founded on the prior determination of principals' therapeutic objectives. By following such strategy, a therapeutic objective is stated for a rehabilitation session.

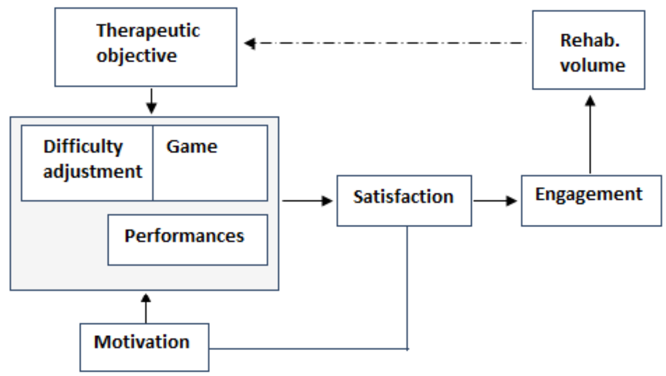

Figure 3. General Difficulty Adjustment Framework

For example: increasing the range and smoothness of the impaired arm movement.

Once the therapeutic objective is set, therapist chooses a sequence of therapeutic games that fulfill this objective. The patient-game interaction generates a set of observable data that are collected and referred to generically as performances. The adaptation module uses this data to adjust the task difficulty.

Our approach for motivation is inspired by the adequationist paradigm relating to the satisfaction of an individual in job [19].

In this approach, motivation is mainly considered as a regulation process. When the reality (outcome of a therapeutic game) is consistent with the expectations of the patient (perception of own motor skills) then this is considered as a stabilized satisfaction state. The patient attempts to provide efforts to maintain this steady state.
In the case of a minor disruption (constructive dissatisfaction), the patient may produce efforts to regulate his satisfaction state. However, in the case of an important disruption, the patient could fail in producing efforts to regulate his satisfaction state entering him in a demotivation situation.
The difficulty adaptation module is asked to produce con-

structive dissatisfaction situations to keep the patient engaged in the therapy. As consequence of patient's engagement, the rehabilitation volume (I.e total time and number of exercises) can increase. As it is shown by several studies [4] [18] the rehabilitation volume increase results toward a better achievement of therapeutic objectives.

C. Motivation Model

Different motivation models are proposed in the literature and these models strongly depend on the application domain. In post-stroke therapeutic games point of view, motivation can depend on several factors such as: success and stimulation, feedback on activities, autonomy, self-esteem, meaningfulness and variety of tasks.

In this paper, the proposed motivation model is limited to the principles of the activation theory [30] since it fulfils most of previous mentioned factors. This theory states that stimulation is necessary and the use of an activation level is required in order to make an individual sufficiently motivated to perform his tasks. This theory seems to be adequate to be used in therapeutic game context where the stimulation can be controlled by adjusting the difficulty level.

As a measure of the level of activation, we have considered the ratio between the probability of encountered successes and failures for a patient [30]:

Activation(n) =

$$\begin{cases} log(\frac{Pr_n(success)}{1-Pr_{n-1}(success)}) & \text{if } Pr_n(\text{success}) \neq 1 \\ 1 & \text{otherwise} \end{cases}$$

$Pr_{n-1}(success)$ represents the proportion of successful games from all prior games.

The cumulative activation score is simply a sum of all activation scores:

$$\sigma(n) = \sum_{i=1}^{n} Activation(i)$$

This measure keeps a memory of all activation scores achieved by the patients. It provides a global trend of the motivation that is not affected by local variations.

To represent local variations, we introduce also a derivative measure on activation scores:

$$\delta(n) = Activation(n) - Activation(n-1)$$

This measure indicates the direction of the current motivation score when compared with the previous one.

D. Abstract Model for Difficulty Adaptation

As mentioned previously, it is important to conceive the difficulty adaptation module at the abstract level in order to reuse it in different games. To achieve this, we introduce a structure called: matrix of action probabilities. This matrix represents the 2D plan of the game and each place $D_{(i,j)}$ holds a probability that an action should be performed at this location by the patient. Having this information, the game level has to direct game actions towards places with the highest probabilities.

The advantage of this structure is to offer a common interface to all games. Thus, the game level considers the difficulty adaptation module as a black box producing a matrix of action probabilities.

To construct the matrix of action probabilities by taking into account the presence of challenge in the game, it is necessary to collect some information on the patient. This step is called the assessment and produces a matrix where each place $A_{(i,j)}$ represents a success rate of the patient.

Finally, the difficulty level is expressed as a desired success probability (d) for the patient. This is interpreted as the willing of having the patient succeed with the probability at least of $d\%$.

In this case, the relationship between the two matrices is as follows:

$$D(i,j) = \begin{cases} \frac{1}{\#\{A(x,y)\geq d\}} & \text{if } (A(i,j) \geq d) \\ 0 & \text{if } (A(i,j) < d) \end{cases}$$

Where # denotes the cardinal of a set (number of elements) This states that all places where the patient is supposed to succeed with at least a ratio of d are selected with equal probabilities. All other places are given a probability of 0 so the game level ignores them.

E. Difficulty Adaptation Process

In our approach, the difficulty of a task is related to its probability of success. Higher success probability indicates low difficulty. Conversely, lower success probability indicates higher difficulty. The difficulty adaptation module takes one of three decisions depending on the patient's profile and motivation: increase, decrease or maintain the current difficulty level of the training session.

Three criteria are taken into account for adjusting the difficulty level. The first two criteria $S{+}_{\text{local}}(n), S{-}_{\text{local}}(n)$ measure the local instability of the motivation in both direction increase and decrease respectively. The third criterion measures the overall trend of motivation.

These criteria are calculated as:

$$\begin{aligned} S{-}_{\text{local}}(n) &= \frac{\#\{\delta(i) < 0, i \in [n-w, n]\}}{w} < {\omega^{+}}_{\text{local}} \\ S{+}_{\text{local}}(n) &= \frac{\#\{\delta(i) >= 0, i \in [n-w, n]\}}{w} < {\omega^{-}}_{\text{local}} \\ T_{\text{global}}(n) &= \text{Trend}(\sigma(1), \sigma(n)) \geq \omega_{\text{trend}} \end{aligned}$$

w is a parameter that determines the size of the window to calculate the local fluctuation of motivation. ${\omega^{-}}_{\text{local}}$ and

$\omega^{+}{}_{\text{local}}$ determines thresholds of success and failure ratios in the local window. T_{global} represents overall trend of motivation. A least squares method is used to calculate this trend on the cumulative motivation [1]

With these elements the algorithm makes the following decisions:

- $S-_{\text{local}}(n) \wedge \neg T_{\text{global}}(n)$: decrease the difficulty. Indeed, this is interpreted as a local degradation of motivation and a global trend indicating demotivation.
- $S+_{\text{local}}(n) \wedge T_{\text{global}}(n)$: increase the difficulty. This is interpreted as a local and global increase of motivation: the patient is succeeding too easily. The difficulty is increased to keep an acceptable level of challenge.
- in other cases, do not change the difficulty.

In addition, assessment is used in the initialization step for the adaptation module which will decide on game parameters such as the initial difficulty distribution matrix values and the initial target starting point. Once a round of the game is played the module makes decision about increasing, decreasing or using the prior difficulty matrix.

V. The Pilot Experiment

A. Protocol

To experiment with the presented adaptation approach we have conducted a pilot study with healthy players. In fact, before experimenting with patients and disturb their classical rehabilitation program (planned for at least five weeks), it is necessary to experiment firstly with healthy persons. Nonetheless, the experimentation scheme with healthy players has to simulate difficulty conditions - based on movement coordination on a 2D plan - similar to the ones that patients could encounter during their upper-limb rehabilitation program. The proposed game difficulty levels are adapted to healthy player and thus the game is considered in this case as a training tool for them.
The experiment follows an independent-measures design with two independent groups. Group 1 uses a difficulty adaptation strategy that provides a random game task difficulty and Group 2 uses the proposed difficulty adaptation strategy.

For both groups the experiment was conducted in a similar way. An initial assessment allows us collecting prior data about the player's equilibrium capabilities. The user's profile was then constructed using the functional measurement deduced from this evaluation test. This initial assessment also produces the difficulty matrix for the first round of the game. In addition, at the end of each round player's performances allow the system to generate the task difficulty for the next round. Besides, at the end of each round, the player reports on his own perceived difficulty using the DP-15 scale [8].

[1]These parameters has been set experimentally as follows: w=5, $\omega^{-}{}_{\text{local}}$=0.6, $\omega^{+}{}_{\text{local}}$=0.6, T_{global}=.25

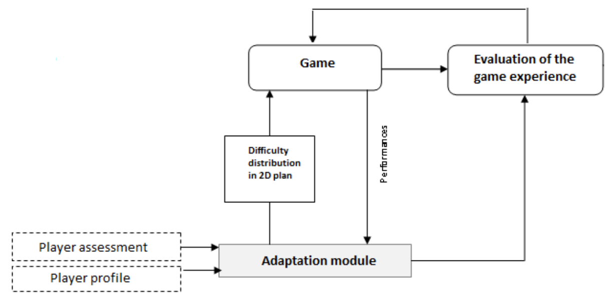

Figure 4. Difficulty Adjustment Process

B. Participants

Each group was composed by 4 persons with the following characteristics:

Group	Gender	Age	Dominant hand
1	3M 1F	(23.25 ± 3.59)	4 right
2	3M 1F	(24.25 ± 2.22)	3 right and 1 left

C. Hypothesis

The aim of this experiment is to demonstrate that the proposed motivation-based difficulty adjustment technique influences the player's motivation and his perceived difficulty. Our objective is to create a game experience in which we (i) provide task difficulties appropriate to the player's capabilities in order to train him and thus improve his motor skills acquisition (ii) support player's motivation by (a) maintaining the balance between success and failure rate while creating constructive dissatisfactions and (b) influencing positively the perceived difficulty.
In order to check the difference between the two groups, the balance between success and failure rate propriety and the system influence on perceived difficulty, the following hypotheses are stated:

- A.H0 There is no difference between Group 1 and Group 2 concerning the success rates.
- B.H0 There is no balance between success and failure proportion in Group 1.
- C.H0 There is no balance between success and failure proportion in Group 2.
- D.H0 The perceived difficulty in Group 1 is different from Group 2.

D. Discussion of the Results

Results are reported as (Mean $\pm$ Standard Deviation). All statistical analysis was performed using R (http://www.r-project.org) version 2.12.0. A Chi-square test for independence was used to reject A.H0, Chi-square goodness of fit test to reject B.H0 and C.H0 and t-test to reject D.H0.

Group	Success	Failure
1	101	99
2	185	81

Chi-square test shows that there is a significantly difference between Group 1 and Group 2 in term of succes rate, $\chi^2(1, n = 466) = 17,475$, $p = 0.01$.

Group	Success	Failure
1	48,871%	51,128%
2	69,322%	30,678%

Only Group 1 using the difficulty adaptation strategy fulfills the balance between success and failure proportion propriety. The χ^2reject so B.H0 as success and failure proportion are both proximately 50% in Group1. As for Group 2, the C.H0 hypothesis has not been rejected by this test.

Finally, the t-test shows that the perceived difficulty was been proximately the same in both groups, t=0.2641 , df=6 and standard error of difference = 0.946. Hence, the D.H0 was been also rejected.

In our experiment, A.H0, B.H0 and D.H0 have been rejected. These results indicates that dynamic difficulty adjustment influences the player's motivation not only by challenging him (see game motivation concepts [21] but also by maintaining his success rate and influencing his perceived difficulty.
For a therapeutic game performing slightly difficult tasks but in a good mood is more important than performing less difficult tasks and being bored. In fact, in the first situation the duration of the session can be extended which is our main objective: increasing the rehabilitation volume.
Despite the use of a strategy based on challenging the player by maintaining his dissatisfaction and satisfaction, which causes a high failure rate versus the non adaptive technique, the perceived difficulty was been proximately the same in both groups. In fact, the proposed technique allows challenging the player without frustrating or boring him. This can be performed by maintaining the balance between success and failure rate in the game session and decreasing the level of the player's perceived difficulty.
Thus, the motivation-based difficulty adjustment is important because it avoids letting the user in a situation of failure by decreasing difficulty so the user can be again in a situation of success. Using the questionnaire about perceived difficulty, we have also observed that users are very influenced by recent performances. In fact, they seem to be more influenced by recent performances and forget earliest results. This highlights the dynamic and temporal nature of motivation and frustration when playing therapeutic games. We have also remarked that cumulated failure (a window of 10 failures) has more influence then cumulated success on player's perceived difficulty and thus on his motivation.
In addition, we can note that the player's decision-making concerning perceived difficulty depends on different factors and change from a player to another. These factors can be related to eye-hand coordination, effort for doing the task and the game constraint (reaching target, timeout, and target distance)
These observations need to be conformed experimentally in a future works. Finally, for this pilot study the focus was on evaluating whether the motivation-based model has controlled the difficulty of games and not on the outcomes of the training. Future studies could extend the presented experiment to evaluate differences in term of learning skills between a classical approach and an approach with motivation-based difficulty adjustment.

VI. Conclusion and Future Works

Serious game in post-stroke rehabilitation is a promising application domain. The usefulness of such virtual-environment based rehabilitation strategy may consist in the possibility to provide a personalized rehabilitation session in which the intensity of training, presence of challenges, feedbacks and motivation are adapted to patient's capabilities, profile and performances. We focused in this paper on the adaptation of therapeutic game difficulty. We have proposed a generic difficulty adaptation technique dedicated to a family of therapeutic games for upper limb rehabilitation. The proposed technique is based on the user's profile and on a prior assessment of his physical capabilities to dynamically adapt the game experience.
In order to test the effectiveness of such approach we conducted a pilot with two independent groups. Group 1 used our proposition for difficulty adaptation and Group 2 used a strategy that suggests tasks with a random difficulty. Results show that for Group 1 the strategy used influenced motivation more than for the other group. The difficulty adaptation strategy, in fact, provides a balance between success and failure rate in a game session and decrease the perceived difficulty level while challenging the player.
Actually, as stroke patients' failure rate is usually high in day-to-day rehabilitation, our adaptation technique could show his potential on decreasing the perceived difficulty of tasks and thus maintaining the motivation.
While for this experiment focused on healthy people, once the motivation model is more stable we want to test it on stroke patients. To test on stoke patient, we will keep the same collecting data principles with some additions for the users' profiles such as general data concerning the time since the stroke, left/right stroke or neglect effect presence. These indicators could be used by the adaptation module to choose the appropriate strategy according to the proposed therapeutic objective.

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