Using Procedural Content Generation for Storytelling in a Serious Game called Orange Care

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***Abstract*—It is well known that the use of Procedural Content Generation (PCG) techniques is commonly used in the digital gaming industry because of its efficiency in solving problems and consequently reducing development costs and time. In particular refers to a computer program that automate the game's content creation process, reducing the manual effort of human work. The choice of the technique also can be useful in other situations like compression of game data, save memory space, and others, but the implementation of the PCG technique requires a mastery over the problem that will be solved, because for each type of problem there is a type algorithm to be considered. The proposal of this research consists in the application of such technique for the automation of construction of characters and scripts for a serious game. The objective of this game is to convey educational content about skin lesions to primary care physicians. Within the game there are characters who are patients that have different phenotypes and skin blemishes, and the player must analyze if the stain contained in a patient is a cancer (melanoma), and subsequently decide if that patient should be referred to the dermatology sector or not. The implementation of the technique is based on generating these patients and the scripts with different peculiarities, taking into consideration the level of knowledge about the skin lesions that the player possesses to provide education and fun adapted to him. The results presented in this work are just tests of the implemented algorithms, but can be considered as in-game practical results, since the game was not tested with the main public yet.**

***Keywords*-pcg; script; story; game;**

I. Introduction

The evident growth of Digital Games Market and its competition highlight the need of the challenge and fun improvement provided by those games and also the players' expectations, which results in a more complex environment of game development. Considering this aspect and the interest of players about fun [1], the objective of game development also embrace optimization on content creation process. For that matter, it is well known that the game development environment can require a multidisciplinary team, specially when it has an educational purpose, which means that the team must stand up to communication and understanding barriers and also worry about the deadline and budget.

With regard to time development and its proportion against the team dimension, developers aim to reuse contents like sprites, codes, sounds and others assets. That can be complicated because a game which requires many characters or a complex storytelling may compromise the deadline and the budget, considering that it also requires more human effort on the creation process [2][3]. The Procedural Content Generation (PCG) techniques are commonly used on digital game industry to support this need, though. But for that, it is needed an abstraction of what is content to be generated by the computer.

In short, PCG consists of an approach that uses algorithmic solutions to build game content, which means that needs data input and output with or without human interaction in the process [4]. In particular as design tool to instigate the creative creation process. Game content or game elements are terms used as abstraction for maps, levels, items, history, characters, rules, weapons and whatever implies on gameplay [4]. In an effort to ensure a good functionality of this approach it is important to consider the restrictions of the game, for instance: a generated cave where there is no exit [5].

This way PCG takes as a main challenge build a playable environment that don't mess up with the player's fun, considering that game content will be generated automatically. In another words, do not generate incomplete scenarios, impossible puzzles, levels without end, and preserve a non-repetitive gameplay which could discourage the player.

Among the PCG's purposes solutions there is one in particular which refers to the use of PCG techniques in this work, that is used for the Stories construction in a Serious Game called Orange Care (OC). The main proposal of this game is to simulate the clinical environment of a Basic Health Unit (UBS) attendance in Brazil, where the player can make lesions pictures analysis to make one of two decisions: designate the patient to an expert in dermatology or dispense the patient of another medical exam. The goal is to use the game mechanic to promote knowledge about skin cancer while quantifying the acquired knowledge.

There are two elements of PCG considered in Orange Care: characters generation and stories generation. Consider-

ing that patients consists of many characters, it is unfeasible to develop one by one. Also, they have different phenotypes and skin lesions, which must contains different peculiarities, considering the player's level experience and also the content previously generated. Concerning the novels scripts, the abstraction of spatial configuration and plot points as pointed by [5] will be represented as chat-windows where players can achieve goals answering questions and completing the already generated narrative.

II. Theoretical Background

In this section we provide a theoretical basis for the development of this work. It is divide in Section X which presents a literature background regarding educational games and Section Y that goes through the Procedural Content Generation technique.

A. Educational Games

The ludic features present in digital games have as its aim to provide the player's immersion and involvement. This game's characteristic is useful to transmit a serious content in an attractive and dynamic manner. Games with this purpose are called Serious Games, and they try to make use of this attractive approach while keeping the whole material presented with clarity and cohesion [6].

Elements that can contribute to a player's fun when experiencing the game are: the fantasy, the challenge to achieve a mastery, rewards, leveling up, constant evolution, the gameplay (experiences inside the virtual environment of the game), flow and immediate feedbacks from the interactions with the game. The practice of these elements in an educational game can be better accomplished when followed by professionals such as pedagogues, teachers, psychologists or instructional designers. These professionals can contribute for a better learning with the audio-visual content and its interactions from the learners [1].

As another tool for promoting learning, *Gamification* uses the features aforementioned in other contexts, intending to engage the participants in the gamified process (turning something in a game-like product) [7]. Classical gamification elements like scoring and players' competition could be not desired in classrooms. However, other elements of gamification could be used to improve the player's involvement like completing all the steps of a determined task [8].

As yet another tool, there are the virtual simulations, operating as support for professional's training [9], academic research assistance [10], gastronomy [11], learning assistance [12], human behaviour prediction [13], sales [14], business [15], among others.

When producing ludic content for a simulation or gamified system, the difference (sometimes tenuous) between games, simulator games and serious simulators must be considered. The features of these applications can be distinguished by the project aspect observed by the user's point of view, as proposed by [16].

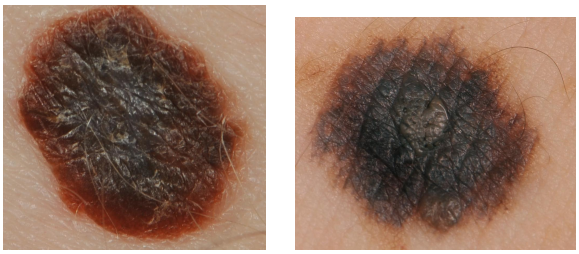

Figure 1. Melanoma at left and a neavu at right (UMCG).

III. Skin Lesion Images Collection

As mentioned before, the OC game makes use of lesion pictures, what most of them is dermatoscopy. Those images was acquired through 9 data bases with melanoma and non-melanoma types, but just 5 of them provides free access to the content. No Brazilian database was found, at best the game also can make a contribution supporting a database construction with new skin lesions images, using its own mechanism to upload these images. Two typical images of these databases, one presenting a melanoma and other non-melanoma respectively is shown at Fig. 1.

The first database is called ISIC-ARCHIVE which contains 13.791 images with well described pictures with lesion and patient info. Second database is from Dermatology Department of University Medical Center of Groningen (UMCG) that contains 70 images of melanoma and 100 nevus pictures. Third one is the DermNet NZ containing lot of images but the source do not gives an exact count. Fourth base it's called Dermnet - Skin Disease Atlas, with few images and poor details. The last one is called ADDI (Automatic Computer-Based Diagnosis System for Dermoscopy Images).

IV. Orange Care - The Game

The main goal of this game is promote knowledge about skin cancer diagnoses for primary care physicians. It is targeted in three environments, the first one in 2D which consists in a mobile phone simulation where the player can interact with the virtual world, that means, talk with non-player characters to complete tasks (Fig. 2). Another one also in 2D, where is presented the skin lesion with the necessary tools for players use (Fig. 3), on this screen, players also can use the chat button to ask questions for the patient. Third and last environment of this list, the 3D scenario where the player's avatar and the patient will be instantiated (Fig. 4).

Also through the simulated apps, players will receive feedback about their performance and progress, as an example, a companion compliment or a formal letter from the hospital director. All these interactions will proceed with e-mails, chat, and others particular apps. With regard to the skin lesion analysis screen, players can move and rotate marks for

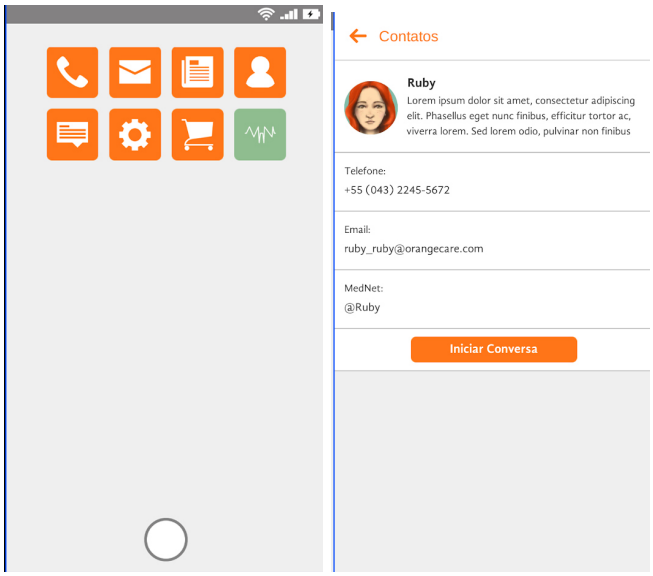

Figure 2. Apps simulation, a list of apps at left and a a non-player character contact at right.

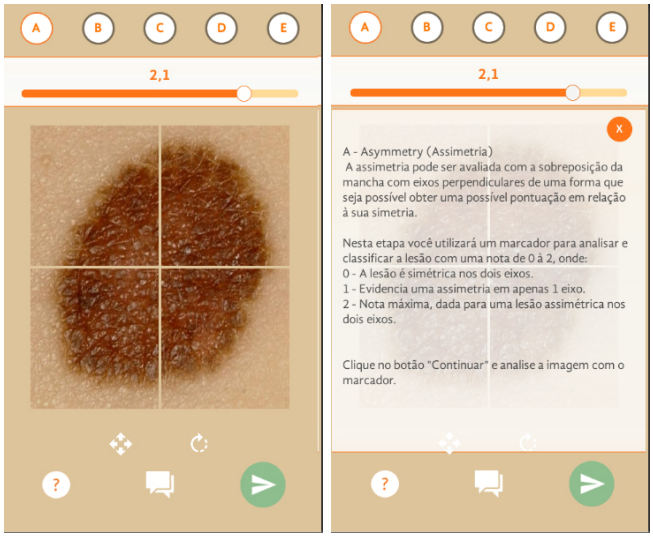

Figure 3. Screen that present the skin lesion picture for analysis.

measures extraction and vote choosing according to ABCD system [17]. Even if patients are generated automatically, which one will get a short narrative with templates for conversation.

V. Characters Generation

As described before the implementation approach for this work can be divided in two stages: the first is the Character Generation and the second the Script Generation. In order to generate the character list, query filters were built to eliminate the non-desirable population (composed by character's features and lesions that were already used). Moreover, the

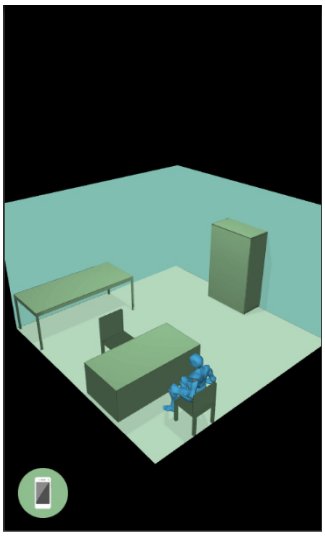

Figure 4. Where the avatars will be instantiated.

player's level is also considered in the query creation, in order to exclude difficult diagnosis images. Therefore, the character's generator algorithm avoids to create previously used characters.

The feature selection for a new character starts with the choice of a database lesion, which determine several physical aspects of the patient, such as age, sex, color, among others. This selection must respect some conditions such as the number of positive and negative diagnoses for melanoma. This kind of condition helps in the execution of the second PCG step of this game.

A list of patients is generated for each playable *Act*. We consider as an *Act* a sequence of goals that the player must complete so that a next round is generated. Following the same idea, the second stage of PCG was created, that consists in generating a script with dialogues of common characters and patient characters, texts of emails, SMS, among others. This second stage takes as its main goal a mathematical proposition, which can be interpreted as several states that must be modified for a new Act to be generated. Each mathematical proposition represents a general goal of the Act. Two examples are given in Table I.

As it can be seen in Table I, in order to increase the hospital popularity, the goal includes two states: *do not know the patient* (¬Met (Patient1)) and *patient not yet diagnosed* (¬Diag (Patient 1)). In order to gain points for the hospital, the player must have the same proposition state, i.e. the result must be *met patient* (Met (Patient1)) and *patient diagnosed* (Diag (Patient1)). Therefore, the game considers the goal as accomplished and brings another challenge.

Moreover, the list of goals accomplished in the previous Act is considered for the script generation. Thus, the mechanism tries not to generate equal goals consecutively, even

Table I
TWO EXAMPLES SHOWING PART OF A PROPOSITION THAT REPRESENTS AN GENERAL GOAL

Goal	Proposition
Gain popularity to the hospital	¬Met(Patient1) ∧ ¬Diag(Patient1)
Earn investments to the hospital	¬Met(Patient1) ∧ ¬Impress(Patient1)

Table II
CONSIDERED CHARACTERS ATTRIBUTES FOR PATIENTS GENERATION

Attribute	Description
id	Unique value to identify the model
sex	characters' genre
age	patient age
race	race of patient, can be White, Black and Hispanic
hexa	Hexadecimal Value used on characters' skin color
lesion	Unique value to identify the lesion
behaviour	Enumerated behaviours as Happy, sad and others
name	Patient's name
model	Patient's 3D model.
torso	T-Shirt sprite
legs	Pants sprite
shoes	Shoes sprite
hair	Hair sprite

if they do not use the same text templates used in NPC dialogues.

VI. RESULTS

Regarding the implementation results of PCG techniques, it was possible to build a mechanism able to receive input such as clothes' templates, bodies and characters' names. The same goes for the script, but new goals can be created according to a effect dictionary, which enables the resolution of complementary goals such as the use of "Met()" and "Impress()" operators.

The attributes considered for the generation and composition of characters are informed in Table II. For each piece of clothing in Table II, a hexadecimal value is assigned referring to the color used in the image, or in another words, the character's clothes' color.

For the character's generator algorithm it was essential to consider the lesion data as starting point because the information from the database defines a great part of the patient's character like gender, skin color, age, among others. An example of a character's image template is shown in Fig. 5.

Tables III and IV list two of the results obtained in the execution of the algorithm with a total of 23 lesion samples

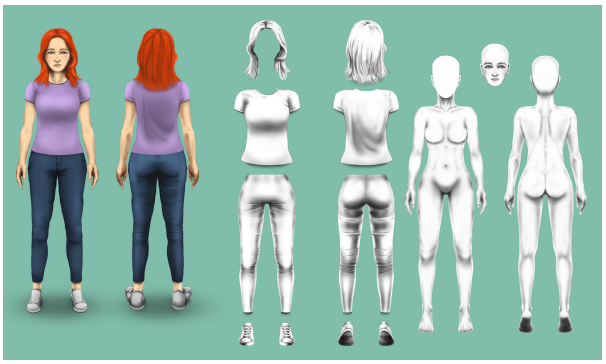

Figure 5. Example of sprites templates for patient characters.

collected from the image database. Features related to 3D models or images such as *torso* and *legs* are represented by indexers of an enumerated set. These sets range from 0 up to 30 permutations of images and colors. It is also worth mentioning that the names used in the character generation are also selected from a set created by the developers and not from the lesion bank.

In addition to the basic attributes already mentioned, the attributes of the lesion bank *member* (body part with lesion), *benign_malignant*, *diagnosis* and *diagnosis_type* were also considered as important. Only the *behaviour* attribute has not yet been tested and therefore has been removed from the table.

For test set, which was partially presented in this work, the program was executed five times with the player's *experience level* equal to three. Therefore, other tests with higher levels may consider more permutations as a result, since more lesions can be selected from the image database.

Regarding the script generation, the results have not yet been evaluated, but the algorithm is in its final stage of implementation. All the screens, mechanisms and templates that will be used by this approach are ready and, in the future, the tests can be performed in the game environment.

VII. CONCLUSION

The results were satisfactory considering the application of PCG point of view was efficient and complied with the initial proposal, what is cut time and cost effort from development. Until now the application of PCG of novel scripts have been performing well, mainly because of the templates previously built which means that mechanic is flowing to keep the users engaged with the narratives. This feature received a particular attention because those textual components makes most part of entertainment.

Concerning about gameplay and fun guarantee, the game OC was not tested with it is main public yet, but after that this PCG model can be put to the test changing those novel templates, with the objective to add new stories, considering all the PCG application is located in a back-end server.

Table III
FIRST LIST OF GENERATED PATIENTS

Name	Age	Lesion	Model	Torso	Legs	Shoes	Hair	#skin
Henrique Gonçalves	45	7	10	15	16	16	17	BB8666
Enzo Jesus Rodrigues	70	2	15	28	26	26	29	E6C6BB
Mariana Costa Carvalho	50	19	8	10	11	13	14	D9A47A
Antônio Almeida Marques	70	8	17	25	28	26	27	C0966C
Daniel Santos	65	9	16	25	28	26	25	B97754
Maria Souza	60	1	14	24	24	20	23	E6C6BB

Table IV
SECOND LIST OF GENERATED PATIENTS, RECEIVING THE RESULTS OF TABLE III AS INPUT

Name	Age	Lesion	Model	Torso	Legs	Shoes	Hair	#skin
Matheus da Silva	15	10	4	5	9	9	8	713920
Benjamin Gonçalves Carvalho	30	0	10	17	15	19	16	D9A47A
Alice Jesus	30	5	6	10	12	13	10	C0966C
Lucas Lopes Moreira	65	17	17	25	25	26	26	F3CBB1
Daniel Martins	20	12	11	19	17	16	15	713920

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