Annote: A Serious Game for Medical Students to Approach Lesion Skin Images of a Digital Library

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Abstract. Nowadays it is claimed that one method to learn how to execute a task is to present it as a gaming activity: in this way a teacher can offer a safe and controlled environment for learners also arousing excitement and engagement. In this work we present the design of the serious game 'Annote', to exploit a medical digital library with the aim to help dermatologists to teach students how to approach the examination of skin lesion images to prevent melanomas.

Keywords: Education · Learning · Serious game · Skin images
Gamification

1 Introduction

The *Gamification* process consists in the application of game-design elements and principles in non-game contexts [16]: it uses the game mechanics to improve skills and knowledge of a subject, also enhancing its engagement and excitement while performing a task that usually does not provides them. Referring to the Csíkszentmihályi [12,19] and Chen [8] studies the sense of fun is strictly connected with the *Flow theory* characterized by the constant steady and balance between the *challenge* offered to gamers and the *skills* developed while facing them: in [5,11,13] are studies about video semantic recognition while the evaluation of affective states and moods are in [3].

An *Exergame* identifies games that are also a form of exercise and involves the creation of a context in which the subject can use certain tools to replicate a series of real movements or tasks: they are used to counteract a sedentary activity, medical rehabilitation and promoting an active lifestyle and they are designed to provide immediate feedback to the player with the possibility of monitoring behaviors and biological parameters.

With the gamification technique it is possible to develop *serious games* which are games designed not only for the pure entertainment: this game genre is focused on the *simulation* feature with pedagogical purpose, by exploiting fun
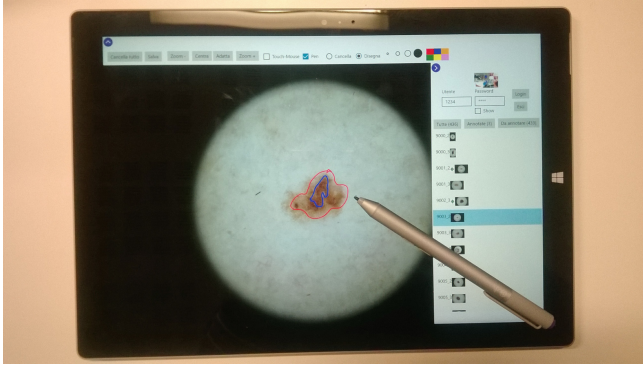
Fig. 1. The original annotation tool developed for Microsoft Surface Pro 3

and competition while used in environments like defense, education [1], scientific exploration, health care [14], emergency management, city politics [17].

The aim of this work is to apply the gamification process to one of the main activity in the daily work of dermatologists with which they make diagnoses and comparisons: the medical image annotation. The paper is organized as follows: Sect. 2 describes the general architecture and the design assumptions taken for the videogame while Sect. 3 shows technical details for the development of the prototype; finally conclusions and future work are illustrated in Sect. 4.

2   The Gamification Process

The idea to develop a serious (video)game for medical teaching (taking also inspiration from exergames) comes from the previous works for the development of an annotation tool [2] (Fig. 1) used by academic dermatologists to annotate skin lesion images and build an integrated medical Digital Library (Fig. 2).

The tool was designed following several interaction principles like *affordance* and *direct manipulation* [20,21]) with the aim to extract a dataset of visual features to use with Machine Learning techniques for a recommendation agent. During a preliminary test session, senior dermatologists and academic interns expressed interest towards innovative learning methods like serious gaming.

The survey of Hamari *et al.* [15] presents ten *motivational affordances* tested on empirical studies about gamification that will guide the design of Annote:

(h1) Score points (h2) Leaderboard (h3) Achievements (h4) Levels (h5) Challenge (h6) Story/Theme (h7) Goals (h8) Feedback (h9) Rewards (h10) Progress

The work of Coltell *et al.* [9] takes up the previous aspects and adds:

(c1) Rules (c2) Safety (c3) Interaction (c4) People (c5) Fantasy (c6) Exploration

The *game objects* is the act of 'draw strokes' and the right use of interactive tools: the *repetitiveness* is a learning element that, differently from commercial videogames, reinforces behavior change and progression in performances [7,22].

The client-server architecture, the tools and the user interface (see Sect. 3) ensures that h8, c1, c2, c3 and c6 are met. A imaginative story (h6 and c5) results hard to introduce if not with the *survival mission* like "save lives as fast as possible" while there is a separate section with a non-interactive tutorial.

The main types of *challenge* offered by the game (c1, h5, h7, h10) are:

1. border challenge (precision): the player has to draw a lesion border annotation that imitates the 'official' one (ground-truth) also considering the completion of already begun strokes
2. structures challenge (recognition): the player has to annotate not lesion borders but groups of skin *textures*, *clues* and *patterns* (lines, circles, reticles, ..)
3. time challenge (pressure): a variant of the previous two where the player must annotate respecting a flowing timer for each image
4. lesion classification (quiz): the player looks an image and gives a diagnosis on the severity of a lesion by choosing from a ranked set (Likert scale).

It must be noticed that the ground-truth has been previously made for the digital library by the academics (or by 'official' algorithms) so this guarantees the quality and the reliability of an annotation chosen for gaming comparison.

The variety of the game (h4, h5, h7, h10) is also given by the *difficulty* modes:

– the type and amount of images chosen by the teacher for a game session
– the activation of aid/impediment game features.

To expand and diversify the gameplay, forms of *rewards* are introduced (h1, h2, h3, h5, h10, c4):

– power-up or penalty: they grant or steal resources to the player (time, points) or enable/disable features like the available tools (zoom, stroke width/color) or their performances (image resolution, mouse/pen speed)
– points and leaderboard: a centralized classification which emphasizes the desire to improve gaming (and learning) performances between students [18]
– personal profile: customizable, summarizes player informations
– badges and achievements: 'titles' that appear in the player profile and in the leaderboard screen; they depend by the number of accomplished tasks and by the amount of gained points.

3   Developing the Serious Game Annote

This videogame allows to draw strokes on an image with different colors (8 choices) and pen sizes (4 choices); the dataset consists of 436 dermoscopic images in standard JPEG format with a resolution of 4000×2664 or 3000×4000 pixels. Large part of design and technology is in common with the original annotation tool and the use of the .NET Framework (ASP.NET with C# the server side, XHTML with Javascript the client side) allows to neglect the problem of the *input mode*: since the client module reaches the server one by a standard web
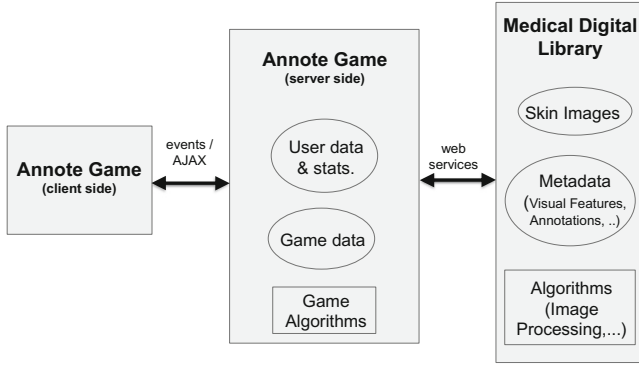
Fig. 2. The system architecture

connection it is possible to interact with the *Surface Pen* if the client runs on a Surface device or with mouse/touch otherwise.

In Fig. 2 there is the system architecture: a *Digital Library* manages the image collection, the ground-truth annotations and the algorithms for visual meta-data as in [4,6,10]; it interfaces with the game server using *web services* that allow communication between heterogeneous technologies; the game client permits the interaction with the user interface exploiting dynamic events and AJAX requests.

The Annote *server* manages data about the registered students with their *points* and *achievements*; the *game data* repository stores the settings of each game task while the *game algorithms* module performs evaluations (for example comparing an 'official ground-truth' annotations with that made by the player).

All gaming interactions and stroke collections are managed locally on the client and the data exchange with the server is limited to the original skin image, the drawn strokes and all the textual data (points, time, task requests, settings): this permits to minimize the network resources and to separate the management of data and algorithms from the module used by students to learn and to experiment on real medical data (that results protected for the privacy). In this prototype the user interface is minimal but functional and it is divided into three main sections (Fig. 3):

– upper section: shows the player profile (photo, nickname, points, badges, ...)
– middle section: tools to manage the image (Adapt, Center, Zoom) and to change the interaction mode (Erase or Draw) or the stroke features (color/width selection, annotation deleting)
– lower-left section: shows the main skin image with the superimposed strokes
– lower-right section: represents the interactive section of the game, in fact shows points and time (for time challenges), the setting of the task and the interactive messages occurred during the gaming session; moreover there are three buttons to commit, reload or change the game session.

Fig. 3. The user interface of the Annote serious game

At the beginning of a game session, an XML configuration file is send by the server to set up the user interface (for example to enable/disable buttons and widgets, instantiate the timer, load the image or draw default strokes). To manage game dynamics like *power-up* or the *increasing difficulty*, the game client implements a simple *event manager* that sends asynchronous messages to the server which in turn raises appropriate counter-events: for example, the end of the time involves a game failure, a *zoom event* will enable/disable the corresponding buttons, a *time X event* will increase/decrease the timer by X seconds, a *speed X event* will increase/decrease the mouse/pen speed by an amount of X. When a student commits his work, the server algorithms will compute the corresponding rewards and will update the total points of the player in the leaderboard rank of the registered gamers.

4   Conclusions and Future Work

In this paper, we exploited the interesting aspect of a pedagogical use of a digital library: help academic physicians in the delicate task of teaching, by transmitting a tacit knowledge hard to express with standard educational modes.

After the prototype presented here, it is necessary to design and perform evaluation studies on the field, involving directly large amount of medical students to obtain qualitative and quantitative data and compare the progressions between the 'standard' learning and the 'gamified' one. A usable *editor* can help to better customize the contents as well as services that address to academic resources when students have doubts; moreover sound and graphic effects with some forms of cooperative or multiplayer features can expand and improve the

gaming experience. Finally, the expansion of this gamification process to other medical specializations that involve annotation protocols may well deserve further insights.

References

1. Ardito, C., Buono, P., Costabile, M.F., Lanzilotti, R., Pederson, T.: Re-experiencing history in archaeological parks by playing a mobile augmented reality game. In: Meersman, R., Tari, Z., Herrero, P. (eds.) OTM 2007. LNCS, vol. 4805, pp. 357–366. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-76888-3_58
2. Balducci, F., Borghi, G.: An annotation tool for a digital library system of epidermal data. In: Grana, C., Baraldi, L. (eds.) IRCDL 2017. CCIS, vol. 733, pp. 173–186. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-68130-6_14
3. Balducci, F., Grana, C.: Affective classification of gaming activities coming from RPG gaming sessions. In: Tian, F., Gatzidis, C., El Rhalibi, A., Tang, W., Charles, F. (eds.) Edutainment 2017. LNCS, vol. 10345, pp. 93–100. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-65849-0_11
4. Balducci, F., Grana, C.: Pixel classification methods to detect skin lesions on dermoscopic medical images. In: Battiato, S., Gallo, G., Schettini, R., Stanco, F. (eds.) ICIAP 2017. LNCS, vol. 10485, pp. 444–455. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-68548-9_41
5. Baraldi, L., Grana, C., Cucchiara, R.: Recognizing and presenting the storytelling video structure with deep multimodal networks. IEEE TMM **19**(5), 955–968 (2017)
6. Bolelli, F., Cancilla, M., Grana, C.: Two more strategies to speed up connected components labeling algorithms. In: Battiato, S., Gallo, G., Schettini, R., Stanco, F. (eds.) ICIAP 2017. LNCS, vol. 10485, pp. 48–58. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-68548-9_5
7. Callaghan, M.J., McShane, N., Eguíluz, A.G., Teillès, T., Raspail, P.: Practical application of the learning mechanics-game mechanics (LM-GM) framework for serious games analysis in engineering education. In: 2016 13th International Conference on Remote Engineering and Virtual Instrumentation (REV), pp. 391–395, February 2016
8. Chen, J.: Flow in games (and everything else). Commun. ACM **50**(4), 31–34 (2007)
9. Colteli, O., Grandi, X., Tosca, R., Latorre, P., Sánchez, J.S., Lizán, L.V., Ros-Bernal, F., Martínez-Cadenas, C.: Designing serious games for learning support in medicine studies: a specific method to elicit and formalize requirements. In: 2014 IEEE Frontiers in Education Conference (FIE), pp. 1–4. IEEE (2014)
10. Corbelli, A., Baraldi, L., Balducci, F., Grana, C., Cucchiara, R.: Layout analysis and content classification in digitized books. In: Agosti, M., Bertini, M., Ferilli, S., Marinai, S., Orio, N. (eds.) IRCDL 2016. CCIS, vol. 701, pp. 153–165. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-56300-8_14
11. Cornia, M., Baraldi, L., Serra, G., Cucchiara, R.: Visual saliency for image captioning in new multimedia services. In: IEEE International Conference on Multimedia and Expo Workshops (2017)
12. Csíkszentmihályi, M.: Beyond Boredom and Anxiety. Jossey-Bass, San Francisco (2000)
13. Cucchiara, R., Grana, C., Prati, A.: Semantic transcoding for live video server. In: Proceedings of the 10th ACM International Conference on Multimedia, MULTI-MEDIA 2002 (2002)

14. Deponti, D., Maggiorini, D., Palazzi, C.E.: Smartphone's physiatric serious game. In: IEEE International Conference on Serious Games and Applications for Health (2011)
15. Hamari, J., Koivisto, J., Sarsa, H.: Does gamification work?-A literature review of empirical studies on gamification. In: Hawaii International Conference on System Sciences (2014)
16. Huotari, K., Hamari, J.: Defining gamification-a service marketing perspective. System **1**(2), 3–4 (2012)
17. Maggiorini, D., Quadri, C., Ripamonti, L.A.: Opportunistic mobile games using public transportation systems: a deployability study. Multimed. Syst. **20**(5), 545–562 (2014)
18. Mäyrä, F.: An Introduction to Game Studies. SAGE Publications, London (2008)
19. Nakamura, J., Csíkszentmihályi, M.: The concept of flow. In: Handbook of Positive Psychology, pp. 89–105 (2002)
20. Norman, D.A.: Affordance, conventions, and design. Interactions **6**(3), 38–43 (1999)
21. Shneiderman, B.: 1.1 direct manipulation: a step beyond programming languages. Sparks Innov. Hum. Comput. Interact. **17**, 1993 (1993)
22. Ushaw, G., Eyre, J., Morgan, G.: A paradigm for the development of serious games for health as benefit delivery systems. In: 2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH), pp. 1–8. IEEE (2017)