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Project and Preliminary Evaluation of VR-MED, a Domain-Specific Language for serious games in Family Medicine Teaching

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***Abstract*—Serious games can be used for training in different areas, like Education and Medicine. In these contexts, it is hard to define game-based learning environments, because this process requires intensive interaction between experts and developers in order to establish common, comprehensible and reusable elements for different projects by both professionals. A domain-specific language (DSL) tends to solve some modelling problems such as the creation and documentation of rules and the reuse of components. This paper presents VR-MED, a graphical DSL prototype for serious games, focused on teaching of Family Medicine. Using a visual notation, developers and healthcare professionals can create simple games based on textual medical cases. A preliminary study shows VR-MED as an adequate DSL to represent Family Medicine elements in a serious game, and that it can be extended to support new medical cases.**

Keywords—Domain-Specific Language; Family Medicine; serious game.

I. INTRODUCTION

Serious game is a solution designed for a primary purpose other than pure entertainment, like training and education [1]. In education, this kind of game is known to be part of what is called Educational Objects (EO). Nowadays the increase in the quantity of EO is quite notable and it can be observed in the Brazilian International Database of EO [2].

In an effort to improve the quality of public health assistance, Brazilian Government created in 2008 the Una SUS [3], a content portal for physicians, nurses and health technicians. Since 2008, Una SUS has granted more than 50,000 positions in specialization and extension courses, using distance learning and traditional settings. These courses encourage the use of EO as a tool to speed up the teaching and learning process and to give more autonomy to the students.

Family Medicine is a discipline of health courses that addresses the first stages of an illness process and the preventive measures for regular diseases. It also considers the social aspects involved in the treatment of a sickness.

Regarding the lack of EO for Family Medicine and taking this area as a specific domain, this work uses Domain-Engineering techniques [4] to develop a graphical Domain-Specific Language (DSL) entitled VR-MED. This DSL is supported by a visual notation that provides the formalism to specify medical cases used under the Problem Based Learning (PBL) teaching methodology. The main goal of VR-MED is to allow non-programmers to create serious games applied to the Family Medicine teaching.

This document is organized as follows: Section II presents a brief related work. Section III presents VR-MED DSL, while Section IV shows a preliminary study about the application of VR-MED during a real training seminar. Section V concludes showing the potential of our DSL approach.

II. RELATED WORK

Family Medicine is a medical specialty devoted to comprehensive healthcare for people of all ages. It is based on knowledge of the patient in the context of the family and the community, emphasizing disease prevention and health promotion [5]. Normally, a family physician is the first contact of the patient with the health system.

Family Medicine students have his/her first contact with the professional practice in this area during the formation process using a methodology called Problem-Based Learning [6]. Under this methodology the student is presented to the problems by short narratives that contain patient complaints and data referent to the emotional and social conditions of those involved [7]. Normally these narratives are presented in a textual form, which limits the interactivity with the content.

In this context, the introduction of computer games allows to create three-dimensional environments that exhibit to the student a variety of situations in the professional's daily life, such as observing the patient's walk, evaluate hygiene aspects of a home, or perceive how a child breathes.

Literature presents some works with prominence in training the relation between the physician and the patient such as in [8] and [9]. The first captures the student's actions in relation with a virtual patient and later let the student review his actions. The second has its focus is on the training in the life support, exposing the student to emergency situations similar to reality by being placed in front of an interactive mannequin.

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In order to facilitate game development, formal methodologies can be used to gather the area specificities. For example, Rieder, Raposo and Pinho [10] define a methodology based on Petri Nets formalism to specify interaction tasks of a virtual reality (VR) and game applications. Broll, Herling and Blum [11] introduce an approach for the development of VR applications based on components. Baresi and Pezzè [12] present a toolbox for automating visual software engineering that augments visual diagrammatic notations with customizable dynamic semantics. Furtado and Santos [13] present the use of a DSL for fast generation of an adventure-type game to be used by non-programmer users.

Model-based approaches are also used in frameworks in order to ease the development process of complex software systems. For example, MASCARET [14] use UML for the design of semantic VR environments, and Collaviz [15] use DSL for developing 3D collaborative VR environments.

Although there are different approaches to formally specify game environments, none of them provides a tool that can be used as a teaching resource for Family Medicine classes. Our proposal is to present a DSL for modelling clinical cases using a notation that allows the code generation for serious games.

III. VR-MED

VR-MED is a DSL prototype that aims to allow the development of serious games applied to Family Medicine teaching. This language is based on a visual notation that offers the formalism for specification of medical learning cases, and can be used to automatically derive simple games from these cases. Even there are tools to improve the game development we haven't identified any research focused on the Family Medicine teaching domain.

A. Construction Methodology of the DSL

The strategy for creating VR-MED was defined during meetings of the Education and Information Group of the University of OMITTED. The main requisites defined for the language were:

- To be suitable for non-programming users to model games from clinical cases by manipulating only language graphical elements;
- To allow the reutilization of the created models;
- To allow the generation of an executable code.

In order to guide the construction of a VR-MED, we adopted an incremental development process of DSLs [16][17], organized in three stages (Analysis, Implementation and Execution) as described below.

B. Analysis and Implementation of VR-MED

In order to collect and register characteristics that were present in the domain, we analyzed textual case studies in the Family Medicine teaching, currently available in Una SUS portal, based on the PBL methodology.

The result of this analysis was a document containing the **conceptual and functional characteristics**, representing peculiarities in the domain. Examples of **conceptual characteristics** are: Physician, Dentist, Nurse, Patient, Medicine, History, Symptom, Complementary Exam, and Physical Exam. Each conceptual characteristic can present a set of **properties** that aid to define the game. The main conceptual characteristic, with their respective properties found in the domain can be seen in Table I.

Functional characteristics represent the domain identified actions, such as: Physician Talks, Physician Asks Symptoms, Patient Accomplishes Exams, Request Complementary Exam, Consult History, Fulfill Physical Exam, Perform Physical Exam, Tell Symptom, Perform Complementary Exam, and Conduct to Specialist. Fig. 1displays an example of the tasks **Physician Asks Symptom** and **Patient Tells Symptom** that were modeled in the interior of a swimlane called **Patient 1**.

Between these two functional characteristics are modeled the Symptoms (conceptual characteristics) of the patient. Note the conceptual characteristics that define a person, like Physician, Dentist, Nurse and Patient, are characters in the game and are implemented by **swimlanes** in VR-MED diagrams. Besides conceptual and functional characteristics, most DSLs, as well as VR-MED, also allow the definition of **flow sequences** that indicate a logical connection of activities. This feature is modeled by lines ending with arrows connecting the characteristics.

A sample diagram was defined in the VR-MED in order to present these two players during a situation in which a physician takes care of a patient at his office, located in a public health center. The patient, named Gustavo, presents a case of hyperthermia, lack of appetite, and has lost weight. Fig. 2 presents this diagram with two swimlanes, one for the patient (Gustavo swimlane) and another for the physician.

TABLE I. MAIN CONCEPTUAL PROPERTIES AVAILABLE IN VR-MED

Conceptual Characteristic	Properties
Beginning of Case	Environment Description, Scenery Representation, Game Title
Talk	Talk Text
Symptom	Patient's Speech, Icpc2, Scientific Name, Popular Name, Image, Sound, Video
Complementary and Physical Exams	Exam Name, Result, Image, Sound, Video
Patient	Height, Age, Graphical Model, Name, Weight
History	History
Physician	Physician's Name

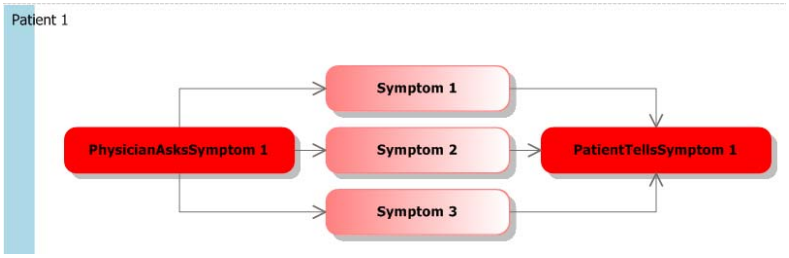

Figure. 1. Example of a VR-MED diagram.

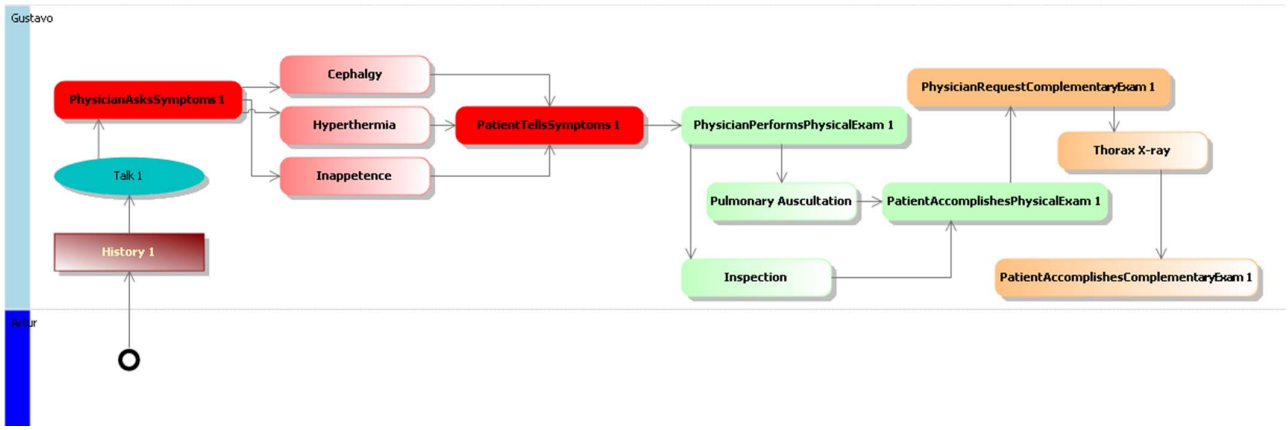

Figure. 2. Medical case diagram modeled by the VR-MED.

1) 2D Player

When reproduced by the 2D Player, the diagram displays a game environment as shown in Fig. 3. Besides the graphical representation of the initial situation, this screen also presents some possible activities (functional characteristics) that the user can choose, by clicking on it. Using of these functional characteristics the user will have access to complimentary exams like the blood, urine, radiographies and physical exams as pulmonary and cardiac auscultation, and ask for symptoms.

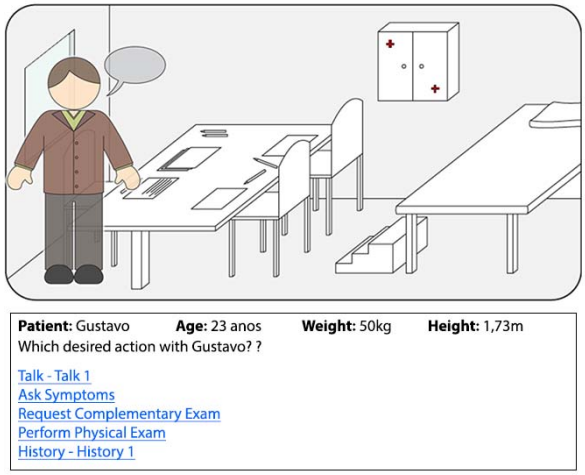

Figure. 3. Game initial scenes in 2D player.

2) 3D Player

From a VR-MED diagram, the 3D Player can exhibit three-dimensional scenes as shown in the upper image of Fig. 4. In this setting that represents a living-room from a residence, the player is able to move around using a keyboard or a joystick.

Functions in the 3D Player operate in an analog way in the 2D Player. The 3D game environment offers to the student a view of the context on where the patient is living, which could be relevant for the diagnosis. This environment also includes animation of 3D models as, for instance, an animated walking cycle. This animation can be reproduced in order to simulate a patient with difficulty to walk, or to move the patient in the 3D settings, to simulate his daily actions. To activate functional characteristics and allow the user to interact with the patient, this player presents a menu over the face of the character, like a context menu, as can be seen on the lower image of Fig. 4.

IV. Preliminary Study

In order to test the use of the VR-MED by a group of healthcare professionals, and analyze its power in expressing the necessary elements of a game that models a clinical case in the Family Medicine area, we applied the methodology proposed by [18] and [18]. This empirical evaluation methodology analyses a DSL on three axes:

- **Model Interpretation:** It verifies the understanding of the model proposed in the VR-MED by health professionals;

- **Problem Representation:** It verifies if it is possible to use the VR-MED to model a game from a textual case study;
- **User's Satisfaction:** It gets the opinion of the users about VR-MED model.

The test took place during a seminar organized by Una SUS. Activities were divided into two moments: firstly, we trained the users in VR-MED during two hours; secondly, after a 30 minute break, we start a two-hour workshop. During this period the participants have used VR-MED to model a typical clinical case employed by Family Medicine instructors and certified by the Brazilian Society of Family Medicine and Community (SBMFC).

A. *Participants Profile*

The workshop had a group of 23 subjects, all working for the Brazilian Public Health System and associated to some actions of Una SUS, as teachers or instructors. All of them have used some kind of computational resources in their classes. The age ranged between 28 and 68 years old, being 15 men and 11 women. Among them, four referred high knowledge of schematic representation based on graphical elements, while 15 had reasonable understanding. Concerning the use of software for creating flowcharts, 11 informed that have never used any with this purpose.

Figure. 4. Images of 3D Player.

B. *Model Interpretation*

In order to measure the level of difficulty in the interpretation of a VR-MED diagram, several questions regarding previously constructed diagrams were presented to the participants. An example of these diagrams can be seen in Fig. 5 that features four distinct areas delimited by red rectangles. Concerning area 01, which emphasized the Beginning of Case element, a total of 21 participants identified it correctly, while 22 did it correctly for area 02. Complementary exams, shown in area 04, were correctly interpreted by all participants. Some answers that were presented were: "…in the doctor's area it shows the beginning of the case.", "Here is where the patient's story begins (visiting the doctor)" and also "…the figure represents the beginning of the case that can be at the health center or at the patient's home in the first contact with the health professional."

C. *Problem Representation*

The participants in this phase were requested to construct a diagram based on a textual case study presented in the questionnaire. The goal was to verify the level of difficulty in using a VR-MED diagram, to describe the medical case presented in a textual Family Medicine case.

The textual case used in the workshop described the situation of a family (father, mother and son) in which the son suffers with the use of drugs and the father presents different symptoms, like nocturnal dyspnea, paroxysm, orthopnea and systematic arterial hypertension. Asking for physical exams, the physician can check that the patient presents edema of inferior members, jugular turgescence, tachypnea, thin crepitant on the pulmonary auscultation base, irregular rhythm, heart-beat by 115 per minute (tachycardia), and systematic arterial pressure of 170/110 mmHg.

Among the constructed diagrams, eight were considered completely correct, five were judged incorrect. Besides these, a group of six diagrams presented a similar problem: the absence of the Patient Accomplishes Complementary Exam element, essential for this medical case. In all diagrams of this group the rest of the schematic were considered correct.

In another group, four diagrams seem to still be in under development when the established time for modeling was over. We reached this conclusion because in these diagrams there was missing a few flow lines to interlink the DSL elements, or the lack of significant names to characterize symptoms or exams.

D. *User's Satisfaction*

Most of the participants (14 ≈61%) judged that the VR-MED has an adequate form to represent Family Medicine elements in a game. This effect can be correlated to the high percentage of participants that indicated having at least reasonable knowledge (19 ≈82%) in representations through the flowcharts. With respect to interpretability of existing diagrams, 16 (≈70%) found it very easy, and 6 (≈26%) found it reasonable.

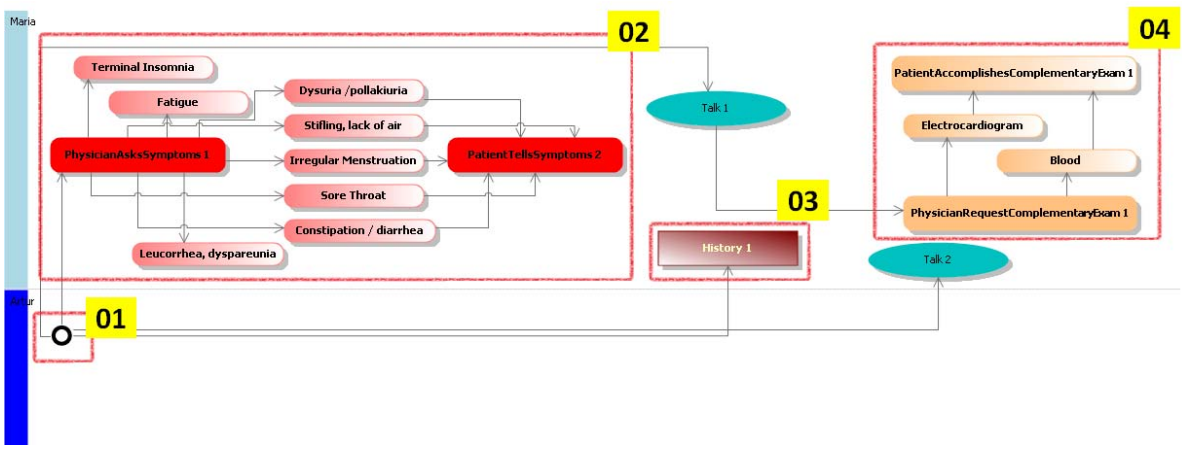

Figure. 5. Diagram used during the evaluation workshop.

Another issue analyzed whether the available elements in the VR-MED were enough to model the proposed textual case. Most of the participants indicated that the currently elements were not enough (52%) to properly represent medical situations. The main reason for that is the current version of VR-MED still does not add new elements to model exams and symptoms in different levels of detail.

V. Conclusions

The use of simulation and gaming in medical applications is already a reality in the professional training. In this context, VR-MED proposes a DSL to build a serious game applied to Family Medicine. Besides the DSL creation itself, an empirical study of the tool took place in a workshop. By the results, VR-MED fulfills the needs of its potential users, but could be improved to support new medical properties.

As future work, it is essential to provide more resources to specify medical cases in different levels of detail. With this in mind, we aim to build a more complete library featuring a larger range of symptoms, physical and complementary exams. In addition, our intention is to offer resources for inclusion of new elements to properly represent medical situations.

In order to consolidate this prototype as a teaching tool, it is also necessary to evaluate VR-MED interface with a large group of subjects considering at least two situations: modeling of textual cases and game interaction.

Moreover, we also intend to improve the web-based players, especially the 3D player. The use of a repository of 3D models and VR devices may increase the visual quality, provide a good sense of immersion and presence to the end user and lead to a better understanding of medical cases.

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