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New Approaches to Linking Clinical Guidelines to Virtual Patients

Andrzej A. KONONOWICZ[a,1], Inga HEGE[b],
Paweł KRAWCZYK[a], Nabil ZARY[c]
[a] *Jagiellonian University Medical College, Kraków, Poland*
[b] *Department for Medical Education, University of Munich (LMU), Germany*
[c] *Karolinska Institutet, Stockholm, Sweden*

Abstract. An often reported challenge of evidence-based medicine concerns increasing use of clinical guidelines in practice. One of the proposed improvements is to promote guidelines by presenting them in conjunction with virtual patients. Three approaches to linking clinical guidelines to virtual patients are presented in this paper: (1) guidelines as a source for generating virtual patients; (2) guidelines hyper-flowchart as a virtual patient progress indicator; (3) guidelines flowchart reconstruction as a learning activity in virtual patient systems. The scenarios have been preliminarily evaluated using two demonstrator applications: Bit Pathways and CASUS. Challenges and direction for further development are proposed.

Keywords. Clinical guidelines, virtual patients, flowcharts, e-learning

Introduction

A long-standing challenge of evidence-based medicine concerns improving knowledge transfer of current, verified, research results into clinical practice [1]. Physicians, unfortunately, insufficiently use summaries of available evidence, regularly published as clinical guidelines, which limits their effect [2]. Vollmar et al. suggested that extending guidelines with case-based patient stories improves their accessibility. The practical evaluation of their guideline-based e-learning platform containing case-based learning resources presented positive results and encouraged further expansion [3].

Case-based learning objects presenting a patient's story are often called virtual patients (VPs) [4]. It should be noticed, however, that the term "virtual patient" (VP) is more general and encompasses all kinds of "interactive computer simulations of real-life clinical scenarios for the purpose of medical training, education, or assessment" [5]. There is already a wide range of VP systems available [4]. Their common denominator is the MedBiquitous Virtual Patient (MVP) format [6].

Clinical guidelines are predominantly text-based, but to improve their understanding they are often visualised using diagrams such as flowcharts. When presented in a web environment, the flowchart may be extended by additional

[1] Corresponding Author: Andrzej A. Kononowicz, Department of Bioinformatics and Telemedicine, Jagiellonian University Medical College, Łazarza 16, Kraków, Poland; a.kononowicz@cyfronet.pl.

information displayed upon selection of the graphical elements [7]. Such a form of knowledge representation is called a hyper-flowchart [8]. Paper-based guidelines may be transferred to formal computer-interpretable guideline formats like GLIF or SAGE [9].

The aim of this study was to investigate approaches for linking clinical guidelines to virtual patients in order to improve the accessibility and the use of best medical evidence in practice. This paper is addressed both to the technically engaged community and to medical educators. For the first group, it demonstrates directions of extending virtual patients and clinical guidelines systems. For the second, it shows the possible implementation scenarios of hyper-flowcharts in medical teaching.

1. Methods

1.1. Mapping of the benefits from linking clinical guidelines to virtual patients

The mapping of the benefits was based on observations made during the use of clinical guidelines and VP systems. Observations of both types of tools have shown the potential to improve procedural knowledge – that is the ability to perform clinical tasks efficiently. The strength of VPs is that they engage the learner emotionally by presenting cases based on real patient stories and allow the interaction with the content in a learning environment (dealing with the consequences of wrong choices, using formative questions and simulations in learning).

1.2. Underlying technical models

Looking at the linkage from the technical point of view, by comparing representation standards such as GLIF and MVP, it may be noticed that they are both based on a form of a flowchart diagram (called "task network diagram" for guidelines or "activity model" for VPs). The tasks (*vel* activities) are connected to object classes (or templates) comprised of attribute values. This data may be shared between guidelines and VPs. In this sense clinical guidelines may be seen as VPs' prototypes and the structure can be automatically transferred.

The second benefit for VP systems connected with guidelines is the flowchart itself, which is often part of published recommendations. A flowchart, presented as a roadmap of the case, forms a condensed visual structure (graphic organiser) of the diagnostic and treatment process which may be memorised incidentally by students while solving the VP case.

1.3. Materials

Two existing software systems were used to inform and demonstrate the presented solutions: Bit Pathways – an environment for authoring of clinical guidelines and pathways [7,10] and CASUS – a VP system with a linear navigation model [11-12].

2. Results

In this section, the following three scenarios of linking clinical guidelines to VPs are presented: (a) guideline as source for similar VPs; (b) guideline hyper-flowchart as VP progress indicator; (c) guideline flowchart reconstruction as an exercise in VP systems (Figure 1).

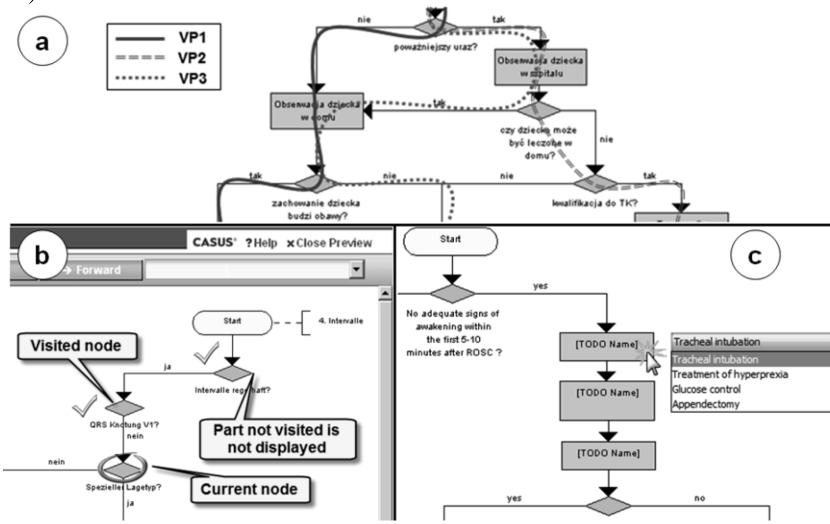

Figure 1. a) guideline as source for similar VPs,
b) guideline flowchart as VP progress indicator c) flowchart reconstruction as an exercise in VPs

2.1. Guideline as source for generating virtual patients

Guidelines in the Bit Pathways environment are prepared using templates that can be exported to different formats including GLIF [11] and MVP [6]. A template is a collection of predefined attributes and attribute groups. Bit Pathways facilitates data transfer between different templates attached to the same flowchart. More than half of the attributes in the "virtual patient" template may have the values copied from the guideline template including values of the card titles, expert comments or links to reference materials. To be filled by the user are the VP screen card narratives (patient story connected with the described algorithm step) and interactive elements checking students' comprehension (e.g. MCQ questions). Pathways with the "virtual patient" template are then exported to MVP with questions in QTI format [14].

The navigation model of the exported VPs can be either linear or branched. In the first case, the learning resource author selects a sequence of flowchart elements to be exported and fills in the narrative fields only for the selected elements. In that way several different VPs can be generated depending on the selected sequences of elements from the root to the leaves of the guideline's flowchart (Figure 1a shows three fragments of selected paths corresponding to three VPs). Designing branched VPs based on guidelines is more complex. The first step is similar to, linear VPs, as the selection of an element sequence forms the "solution path". All remaining (correct) nodes need to be removed, and new "incorrect" steps should be added as alternative solutions.

The proposed scenario has been tested on a flowchart describing diagnosis and treatment of minor head injuries in children. A generated linear VP was exported in MVP format and successfully imported into the CASUS system accelerating the development process of VPs.

2.2. Guidelines hyper-flowchart as virtual patient progress indicator

The second scenario is useful in the case of extensive guidelines for presenting the learner with the position in the guideline's flowchart corresponding to the current stage in the VP solution. The VP exported from the guideline authoring environment retains its original identifiers of nodes in the MedBiquitous package. During a session in the VP system the user can switch to the pathway view to download the current image of the visited guideline elements. The image is generated from the original flowchart by removing those nodes that have not yet been visited by the user in the VP system. Also removed are all edges between nodes from which at least one had not yet been visited (with the exception of edges originating from the last visited node) – Figure 1b.

The whole scenario was verified using a large ECG-diagnosis flowchart constructed in the Bit Pathways environment consisting of 17 subpathways, 49 decision elements with 62 possible diagnosis outcomes. A set of cardiac VPs was designed based on the guideline with links from CASUS cards to Bit Pathways nodes.

2.3. Guideline reconstruction as an exercise in virtual patient systems

In the third presented scenario, guideline construction is implemented as a form of interactivity (or question type) in the VP systems.

The first proposed activity type is to present the whole flowchart with a few decision or task elements in their proper places in the flowchart but with blanks instead of their actual labels. The task of the learner is to select (e.g. from a pop-up menu) the correct labels for the guideline steps – Figure 1c.

In the second activity type, the set of task and decision nodes is retained but the edges between them are removed. The location of the nodes in the picture is changed by arranging them in random order in a column. The task of the learner is to reconstruct the logical topology of the guideline flowchart.

Both exercises types have been piloted with groups of students at Jagiellonian University Medical College, but in scenarios outside a VP environment. The first type of exercise was tested directly in the Bit Pathways editor as part of a reading-with-comprehension exercise. Results of reconstruction of the flowchart elements order was reported in another study [15]. It was demonstrated that the results of manual grading of reconstructed pathways correlated well with the outcome of a MCQ-knowledge test in the same subject as the guideline.

3. Discussion

The presented approaches to clinical guidelines integration with VP systems have opened up a new direction for research in the field and further aspects will emerge during implementations that have just begun. The use of hyper-flowchart in medical education is still rare and formal evaluations will be carried out by the authors in order to confirm the claim that the scenarios actually improve the adaption of clinical guidelines. It is interesting, for instance, how to automatically grade flowcharts which were reconstructed in slightly different form. As this study has shown, more than one order is often correct. The solution may involve design of new tools and methods to give the students feedback in activities involving flowchart construction. Another interesting task for future work is how to embed the proposed scenarios in existing e-learning standards such as MVP and QTI, so as to be understandable by more than one specific VP system such as CASUS.

4. Summary

The presented paper outlines three proposals for linking clinical guidelines to VPs, with the aim of improving guidelines accessibility. The scenarios have been evaluated using two demonstrator applications: Bit Pathways and the CASUS system. Challenges and direction for further development are presented.

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