e-Testing with Interactive Images - Opportunities and Challenges

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Abstract. Modern e-Education systems lack some basic functionalities the e-Testing systems have, such as reuse of question database, random positioning of answer options in multiple choice questions, generation of different tests with the same complexity for students, prevention of cheating by guessing and memorizing etc.

Multimedia is essential in the delivery of e-Learning and e-Testing. However, most of the existing systems include multimedia only as delivery of static pictures and animations without any interaction with images. In this paper we refer to opportunities and challenges the interactive image might have for e-Testing.

We present features of a new human computer interface and discuss the basic architecture of interactive images to be applied in the delivery of interactive e-Testing. At the end we discuss the benefit of this approach and present proof of a concept by analyzing the application domain.

Keywords: Google maps engine, interactive image, e-testing.

1 Introduction

E-Education and particularly e-Learning are modern disciplines that support education and learning processes by sophisticated use of ICT technologies. A very comprehensive overview of methodologies and various interfaces are given by Clark and Mayer [4]. They define e-Learning to be an instruction delivered on a computer by way of CD-ROM, Internet, or intranet with features, such as content relevant to the learning objective, instructional methods including examples and practice, media elements including words and pictures to deliver content and methods etc.

E-Testing is the provision of testing via electronic means. Here we refer to it as a technology delivered mostly via Internet and we are especially interested in cloud solutions as advanced technology for the delivery of massively open online courses (MOOC). A nice overview of existing e-testing systems and their application for e-Learning is given by Gusev and Armenski [8].

Udacity [16] is an example of a MOOC delivery that includes a lot of multimedia elements organized in micro lectures that last approximately 1-2 minutes,

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as kind of explanation of essential knowledge items (learning objectives). Each learning objective is followed by a quiz to assess the student's knowledge. The Cisco NetSpace online learning environment combines several applications for teaching, learning, and collaboration in order to enable an interactive and engaging learning experience [3].

Most of the existing systems include multimedia in the delivery of e-Learning and e-Testing only as static pictures and animations. They lack interaction with images, which includes navigation of the visible part within the image, navigation of details (zooming) or interacting with graphical objects. We refer to this kind of defined navigation and interaction as a technology to deliver *interactive images*.

Application of interactive images in web technology is mostly used in GIS systems, particularly by Google and other providers of web enabled navigation maps. We refer to opportunities and challenges of using this technology for e-Testing in this paper by defining the human computer interface for interactive images.

The rest of the paper is organized as follows. Section 2 analyzes the features of existing e-Testing systems and their graphical user interface. In Section 3, we propose interactive image, a part of the human computer interface, as a technology for e-Testing systems, which includes navigation, zooming and interaction with graphical objects. Google Maps Engine technology, which is a baseline for this system is briefly described in Section 4. Discussion about new developed question types is presented in Section 5. Section 6 discusses the challenges and opportunities of such interactive image system and Section 7 concludes our work.

2 Analysis of Existing Technology

In this section we analyze features of existing e-Testing systems and their graphical user interfaces.

Standard e-Testing Systems are part of e-Assessment, which includes more sophisticated assessment than conventional e-Testing. The main e-testing engine consists of module for user management, including authentication, authorization and accounting; question database module; test generation module; test engine module: assessment module and reporting module. We have presented a highly sophisticated scalable and elastic architecture of an e-Assessment system [14], along with analysis of features and functional descriptions. In the next section we will discuss only those features that give advantage of our e-Testing with interactive images into e-Education systems.

2.1 State of the Art

Most of the existing e-Learning systems only partially realize the e-Testing and do not cover all relevant functionalities presented in the next paragraph.

Question Database is a database with questions and answers capable to be exchanged among different systems and reused in several courses.

Coordinated Test Generation is a feature that enables generation of different tests for each student with same complexity of questions.

Scrambled Options is a technique that presents options of multiple choice questions in random order, so no two repetitive occurrence of the same question will have the same order of offered options.

Negative Score Schema is a method that enables negative grading of incorrect answers to prevent guessing as a method of answering.

Question types have been analyzed by several authors. For example, Crisp presents a taxonomy of question types based on the level of constraint in the item/task response format [5]. A taxonomy or categorization of 28 innovative item types that may be useful in computer-based assessment is defined by Scalize and Gifford [17].

Recently, we have analyzed the multiple choice questions and determined additional deficiencies with the guessing method, despite the negative grading scheme [15]. For example, if a question has three offered answers and two of them are correct, then by answering two questions randomly, a student will achieve at least 0.5 points in the worst case (+1 point for 1 correct and -0.5 for incorrect answer), that is, an always win situation without showing any knowledge. Therefore, we defined a correlation among these two parameters: the number of offered answers should be limited between 4 and 6, while the number of correct answers must be at least 2 and maximum half of the number of the questions.

The classical Graphical User Interface (GUI) for realization of the e-Testing systems is analyzed in the following section.

2.2 Graphical User Interface

Most of the existing e-Testing systems include GUI based on both the mouse and keyboard entry, as presented in Fig. 1. The classical pointing and clicking device is mouse and the device for data entry and navigation is keyboard. In this context we can add that modern graphical user interfaces use touch pads instead of classical mouse devices, either by realization of a special touchpad entry device, or by a screen available on mobile phones, tablets, laptops and emerging new computers. Therefore in the following sections we will use mouse/touchpad as a pointing and clicking device.

Our experience showed that the students prefer the *click test* based only on mouse/touchpad clicks avoiding switch of the input between the keyboard and mouse/touchpad, which initiates lack of concentration while testing. This leads to a situation when the questions are mostly realized as multiple choice questions.

Images are also a constituent element of all existing realizations of e-Testing systems. However, they are mostly used as a static presentation element, which enhances the multimedia presentation only.

So far, the existing e-Testing systems do not use interactive technologies with images, where one can interact with image objects and customize image presentation according to preferred parameters.

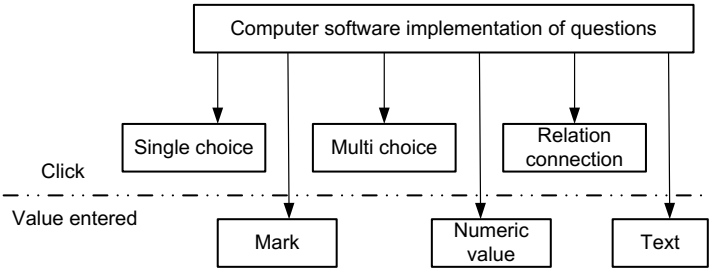

Fig. 1. Classification of question types according to the input device interface

3 A New GUI Model of e-Testing with Interactive Images

In this paper we propose *interactive image* as a technology to realize e-Testing systems. An interactive image is a part of the human computer interface, that includes navigation, zooming and interaction with graphical objects.

3.1 Navigation and Zooming

Navigation and zooming as GUI is mostly understood as an environment where the human sets various parameters for a given image and the system adopts the presentation according to the given parameters. Let the system present only a small image part, called visible image part. These parameters can be at least:

XY position of the visible image part are the parameters that enable navigation by moving the visible part in left/right or up/down position within the complete image.

Size of the visible image part is a parameter that defines the zoom level in the navigation.

The mechanism of defining these parameters can be realized by clicking on specifically defined buttons; by mouse/touchpad drag and drop actions; or by clicking Ctrl (Cmd) button and sliding up/down on the mouse/touchpad. One can also use sliders as an old-fashioned interface to define the position of the visible image part.

3.2 Interaction with Graphical Objects

Besides definition of essential parameters for navigation and zooming, the user can interact with the computer by the following actions:

Object selection is an action realized by mouse/touchpad clicking on the object.

Region marking action is defined by drawing a multiple point polygon, by a series of clicks on consecutive points that define the edges of the polygon.

Setting a pin and commenting is an action defined by mouse/touchpad clicking on a given object and entering a text (comment) for the pin via a conventional keyboard.

Selecting multiple objects action is defined by a combination of pressed Ctrl (Cmd) keyboard button and by mouse/touchpad clicking on several graphical objects.

The left part of Fig. 2 shows an example used in the Computer Network course. The question is to analyze the network and identify the type (router, switch, or bridge) of a certain networking device. Navigation and zooming can lead to present an image portion as in the right part of the Fig. 2. In this case the information in the image portion can be used to make a proper decision and apply relevant knowledge to identify the requested object.

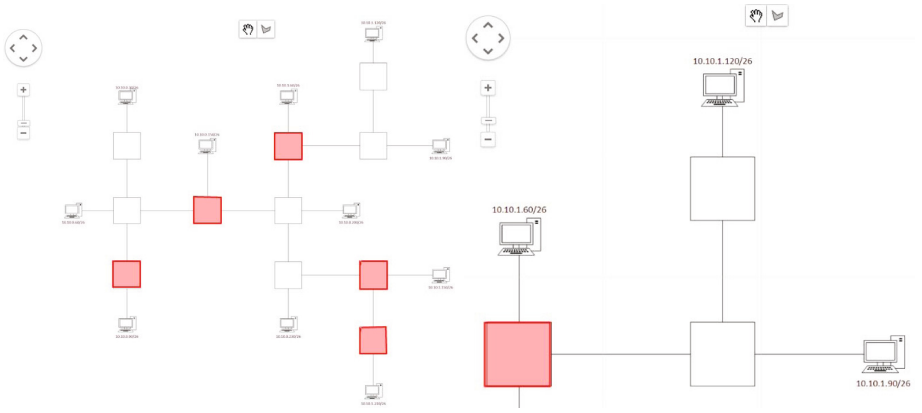

Fig. 2. An example of a question from Computer Network course about networking devices using the eTii system and its image portion obtained by zooming

3.3 Obstacles for Web Enabled GUI

Navigation, zooming and interaction with graphical objects as a human computer interface are integrated in modern existing operating systems. However, we can witness that the web technology enabling navigation, zooming and interaction is only available by small number of providers.

A good example of web enabling interactive images is the Google map engine technology for big high resolution images. The problem that has been solved by Google for realization of Google maps and Google Earth is in the web mapping service, which enables only a small part of a huge image to be transferred to the web browser. This is accompanied by a special preprocessing that defines small images by cutting the huge image into small pieces on different zoom levels and saving them in predefined resolution that will fit for optimized throughput by existing Internet links and presentation on a web browser. The final part is the engine that invokes those small image parts and present a continuous picture environment to the user.

4 Enabling Interactive Image Technology

This section briefly describes the Maps Engine technology and its applications.

4.1 Providers of Maps Engine Technology

Google has used this technology for creation of maps, based on extremely huge satellite images, and enabling a system that defines coordinates and size of a predefined visible image part. Besides the technology, they have been working on marking street maps, by providing a tool to calculate optimized route or business locator.

One of the probably best decisions Google has made is to enable an interface to third party service providers by launching Google Maps Application Program Interface (API) in June 2005, which will increase a possibility for business to use their own maps and for their purposes [18].

Initially it was only a JavaScript API, and later on it expanded to include generation of driving directions, elevation profiles, etc. 5 years after launching as a free service, more than 350,000 web sites use the Google Maps API [6].

Recently, Google has launched new products that enable more sophisticated usage of the Maps Engine API , particularly to enable the enterprises to create, share and publish custom maps [11]. Google Maps Engine API currently only supports a somewhat limited slice of Maps Engines features, which also include basic spatial queries and manipulating vector data, but the team plans to expand the API quite a bit in the near future.

Other providers have build their own APIs. Examples include OpenStreetMap [13], Yandex Maps [21] by a Russian company, etc. Also mobile cell phone providers build their own APIs and maps, such as Nokia and NAVTEQ's [9]. Other big players in the Internet search and e-Business area have also build their own APIs and maps, including Bing Maps by Microsoft [1], Yahoo Maps [20]. Main purpose of these APIs is realization of a geographic information system (GIS) service providing maps of major cities and lands.

4.2 Applications of Maps Engine Technology

Most of the users also see this technology as a tool for GIS enabled systems. Various services have been created using maps, such as the geographical epidemiology mapping [22]. There are examples of using the system even in education [2]. It is considered to be a very successful productivity tool [12]. Juntunen et al. have used Google Maps as a web tool for traffic engineers, helping them for direct manipulation and visualization of vehicular traffic [10].

Although maps are the essential target by Google Earth and similar maps delivering companies, we find that this technology can be efficiently used for other applications, such as education or analysis of medical images. Virtual microscopes use the same approach for interactive images, mainly intended for medicine and biology to enable a tool for individual or collaborative education [19].

In this paper we propose a novel human computer interface for an e-Testing system using interactive images. In addition, this technology also enables tools to organize large datasets and make decisions based on analysis of a given part.

We developed an open-source VM system based on the Google Maps engine to transform our histology education and introduce new teaching methods. The eTii model is based on the architecture model presented in our earlier paper [7].

5 Discussion

Recently, we have developed three new question types, identified as SGC (Single Graphic Choice), OM (Opinion Map) and MGC (Multiple Graphic Choice) [7]. They enable the user to click on a graphical object or point in the interactive image, mark a region where the answer domain is found, enter a textual answer (explanation) on appropriate marked graphical pin, etc. Coordinates of clicked pins, regions and entered texts are sent as answers to the system and further on evaluated by the system automatically or with the support of the instructor.

These results can be efficiently used for e-Testing with interactive Images. In the meantime we have developed a prototype of the eTii system and are in the process of assessing the student knowledge using this system, exploiting the challenges and benefits of the application domain explained in this paper. We have started to create a question database for realization of the course Computer Networks for computer science students.

The process of developing content realized as defining questions is more complex when interactive images are used in comparison to textual multiple choice questions. Besides the developing of a concept for the question, one has to draw a picture, which usually takes a lot more time than just typing a textual question and possible answer options.

Another disadvantage is that not all concepts can be visualized and not any questions be developed. For example, one might rather easily develop multiple choice questions for a definition of a certain knowledge item or learning objective, such as asking "Which option gives the definition of a certain concept?". However, this is not convenient for questions with interactive images.

A typical example of a question with an interactive image is the following "Where can you find an occurrence of a typical object or a concept on the figure?". These question types that include interactive images are application oriented and demonstrate perform skills, when the student is expected to perform according to the obtained knowledge, not just to correlate concepts. They show that the student has deeper understanding of the concept and its application in various context. The main accent is on the application of obtained knowledge and presenting analytical skills to find a typical pattern or concept occurrence, instead of just defining a concept. It is a step forward compared to simply understanding a definition, since the student will not just memorize the concept, but apply its essence in practice, presenting knowledge and skills of applying the concept in various situations and environments.

The classical multiple choice questions are presenting mostly memorizing skills, asking the student to memorize concept names and descriptions. They fit into inform goals that build on learning methods that communicate information.

E-Testing with interactive images evaluate skills, which apply knowledge with perform procedure goals. These goals are based on learning methods that build procedural skills how to realize a certain procedure or perform a task by following steps, such as how to log on or complete a form, etc. The final goal is to achieve a system with perform principle goals based on learning methods that build strategic skills, such as how to design a computer network, how to analyze a communication problem, etc. These questions require the student to to adapt strategies and knowledge to various environments and situations, by applying learned objectives.

6 Opportunities and Challenges

This section gives an overview of benefits, disadvantages, opportunities and challenges this system has in comparison to the classical e-Testing systems.

The main benefits of the new model are summarized as follows.

- The expected image sizes are enormous in comparison to the existing technology to transfer and process these images. The alternative offered by the discussed GUI is promising in terms of being used by a single web browser that loads only small predefined image portions and enables responses in real time by a conventional computer communication network.
- The ability to interact with images enables added value to express application of concepts and not just memorizing of concepts written by textual

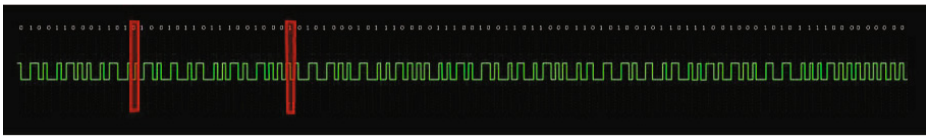

Fig. 3. An example of a question from Computer Network course about signals and coding algorithms using the eTii system

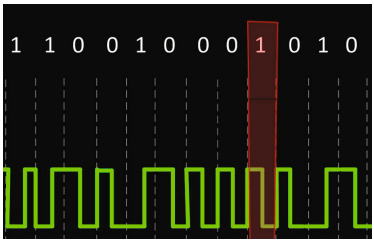

Fig. 4. A zoomed image portion of Fig. 3 displays sufficient information

paragraphs. It goes into the essence of understanding and practical application of knowledge concepts, avoiding just correlating of textual paragraphs.

6.1 Opportunities

So far we have concluded the following add-on values of interactive images to the e-Testing:

Extended domain of options is a feature that extends the domain of offered answer options, by using a possibility to choose enormous amount of positions for possible answers in a huge image. Usually the domain of options in a multiple choice questions is limited by the length of the visible textual part, while the image can offer a lot more positions as answer options. Although Fig. 2 shows only five objects, where one can provide an answer, the example presented in Fig. 3 uses a lot more options where one can provide an answer.

Extended answering possibilities is a feature that offers a possibility to express different answers for selected image objects. In a classical multiple choice questions, the user can select correct answer options for a given question. By using an interactive image with a possibility to set placeholders and comments for each placeholders, one can provide different answer options for each placeholder, meaning that it realizes several multiple choice questions in one occurrence of the image. The example in Fig. 2 enables setting a different answer for each of the five possible objects, as setting a comment in a different placeholder.

Decreased cheating Several features determine decreased ability to cheat. The first one is to avoid using memorization as method for answering, as is done by learning combinations of textual questions and textual correct answers, instead of the essence and context of the questions. In case of images, it is harder to memorize the position of a particular graphical pattern as a correct answer, especially if the image is huge and the visible part can be navigated with its position and size. The second feature is to prevent the ability to use search engines while answering the test. For example, if the question and answer options are textual, one might rather easily find the correct combination, while in the image it is quite difficult to tell the search engines to find the occurrence of this pattern within the huge set of images. For example, it is not possible to memorize the type of the device in the example in Fig. 2, since the IP addresses can be changed in the same image, and the student is expected to apply procedures or principles and analyze the given image.

Favoring creativity and solution discovery instead of memorizing is an add-on obtained by applying the concept to apply knowledge and find an occurrence pattern in an image as an constructive method, instead of matching concept names and descriptions in multiple choice questions, which is reflecting memorizing features of instructional methods. The example in Fig. 3 shows that the student has to apply the coding algorithm and analyze the signals to interpret if the algorithm is applied correctly.

6.2 Challenges

For us, the process of developing content is a really motivating challenge, since not all concepts can have a visual presentation and application. We found that constructive methods that express perform goals and perform procedures, rather than instructional methods can be applied for engineering and natural sciences, as well as in medicine. The application domain in medicine is well known for MRI or cell analysis, but was never been used for e-Testing. The application domain in engineering and natural sciences is rather new and challenging, especially for technology application domains.

There are several challenges that motivate further research.

The first challenge concerns the performance issues. Although the images are stored as small resolution image portions, we expect to face huge data transfers and delays. Especially if a user is anxious and navigates and zooms fast. In these cases, the user can demand a series of image portions to be downloaded from the server.

Elasticity and scalability are challenges to implement a cloud solution and migrate all the functions in an environment that performs as a service. Solving the elasticity problem is not a trivial action. It is not enough to only analyze the transactions and dedicate them to a separate thread, followed by scheduling those threads in a set of virtual machines. A careful analysis and design of an efficient cloud solution would organize the building blocks into static and dynamic modules and map static parts into a static VM, and dynamic parts into a set of dynamic VMs. The development of this solution will enable an environment for a system with more faster response than the conventional thread based approach.

Availability and quality assurance are features expected from any system, especially this one that is going to be used as assessment tool in educational process. Enabling these features depends on third party solutions and services.

Data itself becomes a challenge if it is analyzed by a perspective of a growing database and establishing interoperability of the question database, testing and users information. There are no commonly agreed upon standards among various producers, although several recommendations exist for learning systems.

Security management is always a challenge when building such systems. Managing the firewall and avoiding environments that enable cheating is a top demand of the users.

7 Conclusion

In this paper we propose a new model of human computer interaction for e-Testing that includes interactive images. The model includes features for navigation of the position and size of the visible image part, and also several interaction functionalities, such as, pointing a graphical object in the image, marking a region, setting placeholders in the image, and typing messages in placeholders. This human computer interface for e-Testing with interactive images enables the development of questions that have nature to express constructive skills of the student.

The technology of interactive images is not new, rather it has been in use for delivery of geographical maps by Google and other providers. In this paper we present opportunities and challenges of offering this technology in the e-Testing concept. It allows an extended domain of options in comparison to the limited multiple choice options in conventional systems. In addition it allows more possibilities to provide and answer using placeholders and setting a different answer for each placeholder. The overall system enables less cheating, avoiding memorization, search support and guessing methods as inappropriate.Finally, the system favors creativity and practical application of obtained knowledge towards solution discovery, instead of concept correlation only found in conventional multiple choice questions.

Therefore this technology allows an added value to the classical e-Testing systems, enabling a possibility to test procedural and principle skills rather than just the information concept correlations with multiple choice questions.

Several questions are still open and motivate further research as engineering and scientific challenges. We have analyzed briefly the problems of performance issues as increased traffic, enabling elasticity and scalability of the solution, database organization, interoperability, availability, security etc. Most of these challenges are planned for future work, including experimental research and design of new solutions and models.

The main benefit this system offers in comparison to the conventional one is the add-on value in the pedagogical method of delivery of e-Learning. We have discussed that two approaches used in e-Education as instructivism and constructivism can also have two implementations in e-Testing. The conclusion is that classical textual multiple choice questions are mainly addressing questions applying the instruct learning methods, where a concept is to be associated with some offered answer options. E-Testing using interactive images and described human computer interface can better address procedural skills and constructive methods, where one can apply knowledge in the context of reality.

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