Linked Open Data Visualization with State Hopper: Learning about Europe and its Countries

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ABSTRACT

We present *State Hopper*, an interactive multimedia application that uses Linked Open Data to generate a map-based educational game. A prototype of the system using Europe as map was implemented in a student project. Goal of the game is to move from country to country by learning facts about the countries like population, GDP, size, and others. Each movement from one country to another country on the map generates new insights and allows the player to capture new knowledge about the countries.

Keywords

Educational Game, Interactive Multimedia, LOD

1. INTRODUCTION

Linked Open Data (LOD) is a data model with growing attention in the community and offers data sets from various disciplines. Interactive multimedia applications are a popular way to visualize and publish new content and technologies. The combination of both aspects into a single application is a promising idea. However, today's applications of LOD are often neither very interactive nor do they show common properties of multimedia.

Therefore, we have developed *State Hopper* a prototypical interactive multimedia application for visualizing Linked Open Data. Our application is an educational game as it enables users to explore Europe by discovering facts about its countries. This demo paper describes the concept of the game as well as the development of a prototype, which was implemented by a student group. The target audience of our application is anyone who is interested in getting new insights about European countries in a playful manner. How-

ever, especially children or teenager should be taken into account as the application allows to learn the map of Europe and facts about the countries in an interesting and playful manner. The usage of LOD grants the possibility to enlarge the pool of countries as well as properties and to extend the learning experience to new topics. As we query the LOD sources from different SPARQL endpoints, always the latest information about the countries is presented to the users.

The remainder of the paper is organized as follows: In Section 2, the concept of the game is explained. Section 3 describes the development of the game prototype. Section 4 reveals interesting details about the game architecture. Section 5 discusses related work, before we conclude.

2. GAME IDEA

State Hopper is a single player game in which one travels from a (random) start country in Europe to a target country on the European map as shown in Figure 1. Goal is to reach the target country with a minimum amount of moves (hops).

First, the player chooses at least five properties from a pool of numeric properties that were extracted from linked data sources for each country as shown in Figure 2. Example properties are population, size, area water, GDP (Gross Domestic Product), Gini index (represents the income distribution), and the highest point. At the start of the game, a subset of five properties is randomly chosen and a random start and a random target country are selected. During the game, the player has to acquire knowledge about the different countries to reach the target country on the shortest path. Instead of being able to directly navigate from country to country, the player has to reach the target country by estimating one of the countries' properties. At the beginning all property values are unknown, but will be revealed when moving around. The player has to choose one of the five selected numeric properties to make a move. The value of a property can either be increased or decreased. After selecting a move, every neighbor country is taken into account as the next hop destination. The actual next hop is derived from these criteria: (i) The value of the property of a hop candidate needs to differ in the same manner the player chose (smaller/larger). (ii) The country with the smallest difference in the property value to the current country will be the next hop.
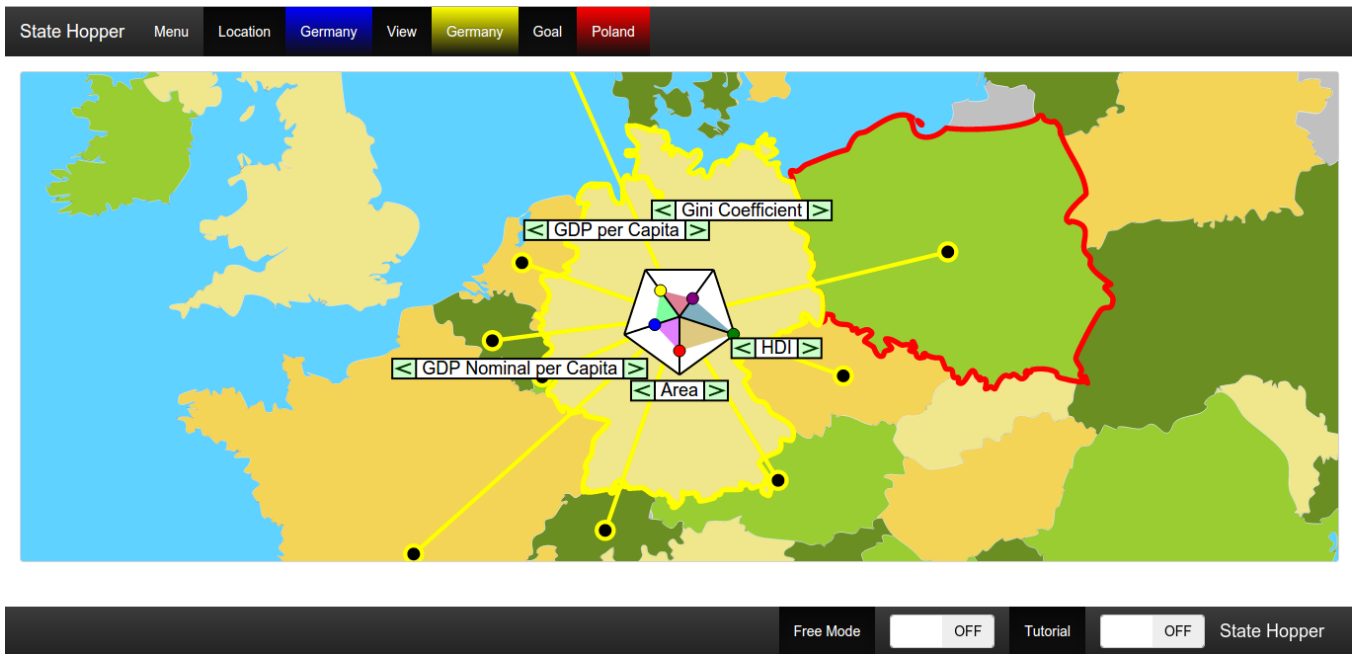
Figure 1: Example of a *State Hopper* run where the player is currently in Germany and the target country is Poland. As shown by the radar plot in the center, the player has already quite some knowledge about the Gini coefficient, GDP, and others of the country. The task is to decide which property to choose in order to do the final move to Poland.
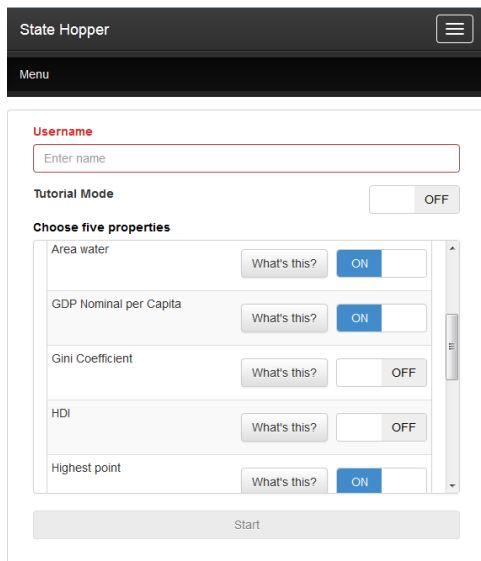

Figure 2: The property selection menu of *State Hopper*

After making a hop to another country, the values for the selected property are revealed for both the origin country and the destination country. For example, Figure 1 shows a screen-shot of a game situation where the player has to reach Poland. The current position is Germany. Radar-plots are used in the game to visualize the values of the properties. As one can see from the radar-plot in the screen-shot, all five properties are already unlocked. During the game, the player can click on any (visible) country to view which countries it is a neighbor of. This is visualized by yellow lines as can be seen in Figure 1. The player has to select a property to move to Poland and decide in which direction the value of the property should be modified by using the '<' and '>' buttons. For example, if the property is population and the player presses '<', it means that the next country will be the one that has a lower population than Germany but still the largest population among the neighboring countries. In the situation depicted in Figure 1, it would be a good choice to decrease the area property, since Poland is the neighbor country which has an area smaller but closest to Germany.

In certain cases a hop is not possible, e.g., there is no country with a smaller/larger value for the selected property. This would be the situation in Figure 1 when the player chooses to increase the HDI (Human Development Index). However, increasing the HDI is not possible since Germany has the highest HDI of the neighboring countries. This can already be derived from the radar-plot depicted in Figure 1, where the HDI value is at the most largest position. Attempted moves like the example that is not possible are counted as penalty hops and the player has to select another option.

Once reaching the target country, the game ends and all unlocked properties are presented in an aggregated view to further strengthen the memory and knowledge of the player. In addition, the player's navigation path is shown to recap the traversal path over the map as shown at the example of the screen-shot in Figure 3.

Besides the 'game mode' described above, there is also a so-called 'free mode' which allows free movement on the map. In this mode, the player can inspect every unlocked property value of any country. It is designed to help the player to remember the choices, learn about the countries,

and discover the map and the country relations. The player may switch freely between the 'game mode' and 'free mode' at any time.

3. PROTOTYPE IMPLEMENTATION

We selected LOD sources that contain standard geographical or economical data like the area or the GDP. In addition, other properties like the number of Internet users or mobile phones are used. For implementing the prototype, a SPARQL endpoint of The World Factbook[1] and DBpedia[2] are used. All data is queried from the SPARQL endpoints at the beginning of the game. The selected properties need to fulfill the following requirements: a) they have to be numeric in order to allow for smaller/larger comparison and b) there must be data available for each country in the game, i. e., for all countries in Europe. During the development process, certain design decisions were made:

Map The basis of the game is a map. A first idea was to use the whole world with all countries. However, finding enough properties that can be retrieved for all countries appeared to be quite challenging. Another option would be to use only the continents, but this would create too few options. Therefore the set of countries of a single continent, here Europe, was chosen.

Restrictions on the countries City-states and very small states are not part of the prototype due to their extreme values for mostly all properties, e. g., Vatican City, Andorra, Monaco, Liechtenstein, Jersey, Guernsey, Isle of Man, Malta, and San Marino. In addition, they have a border to only one country and thus are difficult to reach and they are hardly visible on the map.

Hop selection The next hop to a neighbor country is decided via the minimum difference in the property value. But if there is no neighbor country which differs in its property value in the same manner the player has chosen, an error message is displayed and a penalty hop is added. Furthermore, if two or more neighbors have the same difference, one of the countries is randomly selected.

Start and target country To ensure that the player can reach the target country in every game, a path through the map is simulated from a random start country. The algorithm begins with a randomly selected start country. From there, randomly 10 to 15 hops are executed. The country selected by this procedure is taken as the target country unless it is in the direct neighborhood of the start country. In this case the process is repeated.

4. ARCHITECTURE AND TOOLS

The overall structure of this interactive web application is a client-server architecture using Grails[3] for the back-end and a mix of SVG and JavaScript manipulation for the front-end. Using Grails with Bootstrap[4] makes the application adaptive to different resolutions up to a certain degree

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[1] http://wifo5-03.informatik.uni-mannheim.de/factbook/
[2] http://dbpedia.org/
[3] https://grails.org/, 2015.
[4] http://getbootstrap.com/

Figure 3: Map view at the end of a game with traversal path

(responsive design). The model-view-controller architecture from Grails is used as follows: The model stores all countries and their properties with their corresponding resource URIs for all data providers, in particular the SPARQL endpoints. The map is part of the model as a static SVG file. At the start of the game, all data, in particular the property values, is queried from the SPARQL endpoints and the view is generated. This view resembles a HTML document embedding the JavaScript game engine which runs in the web browser on its own and handles all further interactions. The game engine is based on an event-driven architecture using the browser as event generator. The event processing is mostly done by JQuery[5] which identifies the desired events. Examples are onClick-listener for each country, which is possible since the map is an SVG image containing a SVG path element for each country. Other features like the movement or zooming in the map and the animations over the map are implemented using features of SVG like the matrix transformation of a SVG viewport.

5. RELATED WORK

Educational Games and Games With a Purpose using LOD. Warren and Champion [13] present an approach to generate terrain data for a "Great War" battle game using data from multiple LOD sources. They use the information from Linked Open Data sources to determine where to place what objects in a 3D environment. Our game has most similarity with so called data games which by definition let one explore data as a game. Data games differ from serious games in the fact that they do not (intentionally) have an agenda but provide the capability of exploring data [2]. Multiple data games were implemented by Friberger and Togelius [2, 3, 12] using for example Monopoly or bar charts as the game setting. They used LOD information about the UK in their games. Macklin et al. [5] discussed whether

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[5] https://jquery.com/, 2015.

games are a viable alternative to traditional methods of data visualization and if they can be used for learning.

State Hopper includes aspects of both, data games and serious games, by giving the player the choice to freely explore the data, but also offering an achievable goal. In contrast to serious games which have a specific agenda, the goals in *State Hopper* are of a more generic character and support the knowledge acquisition through playful data exploration.

Interactive Multimedia Applications using LOD. Interactive multimedia applications using LOD are rare. However, there are a few approaches towards media-oriented semantic search like Microsearch that renders a map and timeline next to the traditional result list [6]. Another approach to improve visualization of semantic search results aims at generating simple diagrams like bar charts, graphs, and the like [7]. ResultMaps is an approach to visualize string-based queries in digital libraries by using hierarchical treemaps [1]. In the area of semantic image search is the work by Setchi et al. [11]. The novelty of this approach is that the most meaningful words in the text are linked with ontological concepts. This allows for finding the most powerful set of concepts representing the web document and consequently the images it contains [11]. Towards more interactive multimedia application on LOD, we find faceted search as an approach for exploring a large multidimensional data space [8]. Faceted search has been brought into the arena of the Semantic Web by /facet [4], which allows to explore heterogeneous Semantic Web repositories along the data types they provide. Another work on interactive multimedia employing faceted search is SemaPlorer [9], combining different, distributed heterogeneous Semantic Web repositories including social media data such as photos and locations in an interactive explorative user interface.

The above mentioned retrieval tools and applications are good examples of how interaction is specifically designed to enable users to intuitively formulate queries and interact with the results. In the case of *State Hopper*, the players do not formulate queries but rather hypotheses. By clicking on a lower/higher value of a property, i.e., by making a choice they are testing if their hypothesis is correct. The results of their interaction becomes immediately apparent, i.e., feedback about the properness is directly reflected to the players. Thus, unlike retrieval tools, the user experience with *State Hopper* is more about what one can do with the system and how one can interact with the system [10] rather than querying for results with a minimum effort.

6. CONCLUSION

We have presented an interactive multimedia-based game called *State Hopper* that allows the players to acquire knowledge about countries in the world. The concrete prototype uses the European map and data from different LOD sources to prepare the players' journey. Goal is to reach a specific target country from a randomly chosen start country just by exploring properties like population, GDP, area, and others. First qualitative evaluations with pilot users show that the game makes fun. This is very interesting as the game has a strong educational character. It is quite challenging to create *State Hopper* such that it is enjoying and pleasant, unlike other games like ego-shooters or 3D games that are naturally appealing to the players. By combining different discrete media assets with interactive, navigational elements

and animations, *State Hopper* provides an enjoyable way of discovering relations and facts about countries in a spatial context.

The current prototype can be easily extended to other countries and continents. For example, it could be implemented on the level of the United States of America using Data.gov as LOD provider. A perhaps more interesting extension is to provide support for non-numerical properties as long as an order of the values exists which makes them comparable among the countries. To make the game even more appealing, one could implement various difficulty levels by specifying time limits for each decision. Other game modes could be a multiplayer challenge, e.g., two players compete to reach the target country faster, or unlocking all properties with the fewest possible hops.

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