Cartography Meets Gaming: Navigating Globes, Block Diagrams and 2D Maps with Gamepads and Joysticks

Adrian Weber, Bernhard Jenny, Matthias Wanner, Juliane Cron, Philipp Marty and Lorenz Hurni

Institute of Cartography, ETH Zurich, Switzerland
Email: jenny@karto.baug.ethz.ch

Gamepads and joysticks have the potential to improve spatial navigation in virtual globes, block diagrams and 2D maps. Digital school atlases, in particular, can become more engaging if support for gamepads and joysticks is added, as children and adolescents are very proficient at using these devices. The fusion of gaming devices and interactive school atlases offers interesting new use cases: teachers can control a digital wall map with a remote-control gamepad while lecturing from the front of the classroom, or students can explore maps on their personal computers using an enticing way to interact. This paper presents these use cases, the characteristics of the most common gaming devices, and discusses spatial navigation with gamepads and joysticks for globes, block diagrams and 2D maps. The ideas presented originated from the ongoing development of a new, interactive version of the Swiss World Atlas for schools.

Keywords: game controllers, school atlas, spatial navigation, virtual globe, digital block diagram, *Swiss World Atlas*, NASA World Wind, jinput, digital atlas

SCHOOL ATLASES FOR THE GAMES GENERATION

Today's adolescents and children are used to manipulating gamepads and joysticks for navigating in virtual environments. They pilot aircraft and spaceships through virtual landscapes, meet friends in virtual worlds or fight in shooter games. Why shouldn't cartographers take advantage of these skills and design atlases that are navigable with gaming devices? Since the young generation is experienced at using game controllers, it makes sense to use this equipment for navigating school atlases. Virtual globes, interactive 3D block diagrams and 2D maps, all common elements of many digital school atlases, may become more engaging when combined with gaming devices.

School atlases with game controllers can be considered a special kind of digital education game, or serious game (for a literature overview, see Mitchell and Savill-Smith, 2004). Educational games aim at using the time spent playing for educational purposes while also providing a recreational value. Their goal is to offer an engaging, satisfying and inspiring context that facilitates learning and activates prior knowledge. They serve the needs of the 'Nintendo generation' or the 'digital natives' who grew up on 'twitch speed' computer games, MTV, fast-paced action movies and the Internet (Prensky, 2001). Prensky (2001) argues that exposure to these media emphasizes certain cognitive aspects and competencies. According to Prensky, the games generation seems to prefer visual images to text and has better skills in reading images than older generations. They are better at processing information quickly; they feel much more comfortable when doing more than one thing at the same time; and they are better at connecting different pieces of information.

Consequently, the demands on educational tools have changed too. For school atlases, this implies that 'going digital' by offering zoomable 2D maps is not enough. What students seem to expect are maps of diverse topics that can be combined, viewed in parallel and interactively explored. Atlas software should be easy to learn and offer a rewarding experience.

The basic assumption of this paper is that enhancing a digital school atlas by providing navigation through gaming devices will render virtual globes, block diagrams and 2D maps more engaging and motivating. The fusion of an atlas with game controllers should capture the students' curiosity and interest. It is also hoped that, compared to traditional 2D maps, these enhanced globes and maps will help students improve their spatial thinking and geographical competencies more easily.

The number of digital school atlases with interactive maps increases steadily and a few have integrated rotatable block diagrams or virtual globes (e.g. Diercke Globus Online). None of the currently available school atlases is navigable with gaming devices. Outside the realm of school

atlases, Google Earth is the most ubiquitous virtual globe, featuring satellite and aerial imagery as well as GIS overlays (Google, 2005). The release of Google Earth in 2005 as a free application generated more than 100 million downloads in the first 15 months after its release (Google, 2006) and greatly increased public interest in virtual globes and geospatial technologies in general. Indeed, Google Earth and its 2D cousin Google Maps have set a standard that all atlases and web-based GIS programmes have to measure up to. Microsoft's answer to Google Earth is Virtual Earth 3D, and ESRI has released ArcGIS Explorer, which are similar in terms of functionality and data. All of them use content streamed from the Internet, such as high-resolution satellite imagery, terrain models and vector data in two and three dimensions. Virtual Earth 3D and Google Earth even support game controllers for spatial navigation.

Google Earth has been proposed as a teaching aid (Schultz *et al.*, 2008; Green and Mouatt, 2008); however, Google Earth, Microsoft Virtual Earth 3D and ESRI ArcGIS Explorer are not well suited as school atlases, because they do not meet the specific demands of a school curriculum. The following problems can be identified:

- teachers want ready-made maps that complement the curriculum, if possible, with guidelines on how to integrate the maps into the lectures. They usually do not have the time to search data nor the skills to compose custom maps that are easy and unambiguous to read;
- Google Earth is not an atlas with a predefined collection of cartographically designed maps. Every user can contribute spatial data, which are often not appropriately generalized and symbolized. The resulting maps are difficult to read and the completeness, accuracy and reliability of user-generated data are frequently undocumented;
- a lot of the functionality in Google Earth is not required for teaching, and can be distracting or confusing to novice users (e.g. downloading data from web sites and loading them into the virtual globe);
- it seems that the Google Earth globe is mostly viewed at a large scale, where its aerial images are most impressive. There are relatively few worldwide maps available that are appropriately generalized showing a synthesis of a global phenomenon. Indeed, it seems that most users see the globe as a navigation tool that allows them to quickly plunge into detailed aerial images (Schöning *et al.*, 2008).

These shortcomings led the authors to the development of the concept of a dedicated school atlas integrating virtual globes, block diagrams and 2D maps that are navigable with gaming devices. The concept has been implemented in the new web-based *Swiss World Atlas*, which is currently under development. This new digital atlas will complement the printed version of the longstanding *Swiss World Atlas* (Spiess, 2008). Both atlases are conceived as teaching aids to provide thematic and topographic maps for the regular geography curriculum at the secondary school level. The interactive atlas is not intended for use in complex GIS-type data analysis, nor is it designed as an introductory course to GIS. The goal is to teach students spatial thinking by offering maps that complement the geography classes with

information about the processes, patterns and interconnectedness of geographic phenomena that should train their spatial analytical skills, as suggested by Bednarz and Bednarz (2008) and Kerski (2008).

This paper first outlines possible use cases for a digital school atlas that uses game controllers, and presents the goals that led to the development of this concept. The characteristics of the most common gaming devices are then presented, and metaphors for spatial navigation are discussed. The paper also proposes a way to allocate button actions to movements in space for navigating globes, block diagrams and 2D maps. The *Swiss World Atlas* is then presented and the building blocks of the technical implementation are outlined, focusing on the integration of game controllers.

USE CASES AND GOALS

The manipulation of globes and maps using game controllers was developed for the following two typical use cases:

1. The teacher discusses maps in lecture-style teaching, while a video projector generates a digital wall map on a screen in the classroom.
2. Students use an atlas on their personal computers and explore the atlas in small groups or individually.

The first use case is for a teacher lecturing from the front of the classroom. This kind of teaching has traditionally used paper wall maps that illustrate specific geographical phenomena. With an atlas enhanced by game controllers and a projector, digital wall maps can be projected on a screen in the classroom. The teacher controls the wall map using a wireless gamepad or another device that works as a remote control. Maps can be zoomed and panned, and the topic displayed by the map can be changed at will, while the lecturer moves freely around the classroom and interacts with the students. This set-up differs from normal digital atlases that are connected to a video projector and the teacher sits at a desk behind a computer and controls the atlas with a keyboard or a mouse.

In the second use case, the teacher assigns a task to the students to carry out individually during the lesson or as homework using the interactive atlas. Students can use a keyboard and mouse, or a gamepad or joystick, if available.

The following three main goals led to the enhancement of globes, block diagrams and 2D maps with gaming devices:

1. The attractiveness of the atlas should be increased. The atlas should be fun to use and should motivate the students to explore its content on their own initiative.
2. Navigation with gamepads and joysticks should be easy to use. It should follow gaming standards that are well known to the younger generation in order to minimize the initial effort needed to learn the navigation system.
3. Navigation should also be easy for teachers and students without gaming experience to learn.

The young generation is generally well acquainted with gamepads and joysticks, but users inexperienced in gaming

must not be excluded from mastering a school atlas. All functionalities of an atlas should therefore also be controllable by a traditional keyboard or a mouse, which are familiar to all computer users.

Navigation with gaming devices, however, offers two advantages to navigation with a keyboard or a mouse:

1. It is faster, because simultaneous zooming and rotating (or panning) is easier with gaming devices.
2. When rotating and panning over large distances with the mouse, multiple back and forth movements are usually required to re-centre the map, resulting in a jerking movement.

With game controllers, smooth rotating and sliding movements are possible at an adjustable speed. This helps observers more easily orient themselves in space while watching someone else navigate a globe or 2D map. This is important in a classroom situation, where the teacher operates the game controller and the students concentrate on a digital wall map with a changing spatial context. This observation is related to the report by Midtbø and Nordvik (2007), who found that readers perform better when a 2D map is continuously enlarged with a sliding zoom effect instead of an abrupt magnification.

GAME CONTROLLERS

A game controller is an input device used to control a game typically running on a personal computer or a video game console. Game controllers come in many different variations. Besides keyboards and mice, the most widespread devices are gamepads (Figure 1), followed by joysticks (Figure 2).

A gamepad, also called joypad or control pad, is held in both hands, where the fingers (especially thumbs) are used to provide input. Gamepads generally feature a set of action buttons handled with the right thumb and a direction controller handled with the left (Figure 1, left). The direction controller has traditionally been a four-way digital cross with one button on each end, called a D-pad (for directional pad). Gamepads are the primary means of input for almost all modern video game consoles, but are also available for personal computers. Nintendo launched the first gamepad in 1985 for their video game console, the NES controller, which had a brick-like design. It had four buttons and one D-pad. Today, nearly all gamepads and

Figure 1. Left: the Nintendo NES controller of 1985; right: a modern gamepad with two sticks, a D-pad and multiple action buttons

Figure 2. Left: the joystick of 1977 for the Atari 2600 console; right: a modern joystick with multiple action buttons

many remote-control units for television sets and DVD players use a D-pad, and virtually all gamepads feature two sticks (Figure 1, right).

The gamepad is probably a good choice for steering virtual globes for lecture-style teaching. It does not need to be attached to a table, which allows the teacher to stand in front of the students. Most pads currently use a cable for communicating with the console or computer, but wireless devices are becoming more common. Wireless gamepads are presumably better suited for use in a classroom, as they allow the teacher to move freely in the classroom.

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. In the real world, joysticks have been the principal flight control in the cockpit of many aircraft, but are also used for controlling machines and vehicles, such as cranes, excavators or electrical powered wheelchairs. One of the earliest video game consoles to be bundled with a pair of joysticks was the Atari 2600, released in 1977 (Figure 2, left). Unlike early joysticks that only gave on/off signals for four different directions, more recent sticks provide continuous states by returning an angle measure of the movement in any direction, and feature a set of configurable action buttons.

Joysticks are usually attached to a desk, which presumably makes them less practical for teaching with a video projector and a digital atlas. They are a potentially good option when students are carrying out individual assignments on their personal computer at school or with a video game console at home.

Besides the common gamepads and joysticks, many other alternatives exist, steering wheels, paddles (controllers with a round wheel and one or more buttons), trackballs (upside-down mice that are manipulated with the palm of one's hand), and new devices continue to be developed. The Wii Remote, for example, is a wireless controller for the Nintendo Wii console, which uses a combination of built-in accelerometers and infrared detection to sense its position in space (Figure 3, left). This design allows users to control a game with physical gestures by freely moving the device in front of an infrared detector. For rotating a virtual globe, the controller could be moved like a stick in the analogue hoop-rolling game, where a hoop is rolled along by means of a stick.

Figure 3.   Wii Remote (left) and Apple Remote (right)

Other potentially useful devices are infrared remote controllers that can communicate with computers. An example is the wireless Apple Remote, which only has six buttons (Figure 3, right). The four buttons arranged in a circle could be used to rotate the globe in the four cardinal directions when pressed continuously, whereas a short push on the plus and minus buttons would change the zoom level of the globe.

NAVIGATING GLOBES, BLOCK DIAGRAMS AND 2D MAPS WITH GAMEPADS AND JOYSTICKS

Spatially navigating a virtual globe is considerably more complex than navigating a block diagram or a 2D map. The latter two can be considered simplifications with a reduced number of degrees of freedom. For a digital school atlas with support for gamepads and joysticks, it is essential to design a navigation scheme with the following properties:

1. Navigation with gaming devices should be available for all types of cartographic representations, i.e. globes, block diagrams and 2D maps.
2. Navigation should be similar among the different representations, so that users do not have to learn something after switching between the three representations.
3. Navigation should be easy to learn, feel natural, and make sense to novice and experienced gamers.

Various metaphors have been developed for navigating in three-dimensional environments. The first-person perspective is a navigation metaphor that is common in video games like first-person shooter games, flight simulators or racing games. The virtual environment is rendered from the visual perspective of the player character. Another popular metaphor is the bird's eye-view. This is a view of an object from above, as though the observer were a bird flying in one direction. Fuhrmann and MacEachren (2001) propose the flying saucer metaphor for geographical environments, which would allow the user to hold a position, or alternatively move in any direction (up, down, forward, backward, left, right), turn around the vertical axis, and adjust the up or down angle of the view.

While most 3D games only use a single metaphor, virtual globes have to apply multiple metaphors. The perspective should adapt seamlessly as the user zooms in or out. At very small scales, the user can rotate, enlarge or shrink the sphere. This is not an immersive view; rather it shows the globe as an object from far away. This type of navigation is not commonly found in 3D computer games, which often use the first-person perspective. At larger scales, when the atlas user moves closer to the globe, the silhouette of the sphere is not visible anymore. The perspective changes to the flying saucer metaphor, which facilitates navigation over globe surfaces. At very large scales, the perspective becomes a first-person view with an urban canyon or mountains defining a horizon. This perspective is commonly used by computer games to create an immersive environment.

Spatial navigation in block diagrams and 2D maps applies a subset of these navigation metaphors. Block diagrams are treated as three-dimensional objects viewed from afar. The user can rotate a block diagram around its vertical axis, adjust the pitch angle, and zoom in and out. Navigation in two-dimensional maps consists of zooming and panning in vertical and horizontal direction. The normal northern heading of a 2D map could also be adjusted, but this would be rather unusual.

For navigation that works similarly for globes, block diagrams and 2D maps, the button allocation of game controllers requires special attention. The button allocation defines what action (movement, rotation, selection of an option, etc.) is executed when a button or a stick is activated.

Two-dimensional maps and block diagrams have a limited degree of freedom for navigation, which simplifies the button allocation. For virtual globes, the button allocation is more difficult because the navigation metaphor changes with the display scale of the globe. At small scales, the user handles the globe as if it were a distant object. Thus, the button allocation is similar to the allocation in block diagrams and 2D maps. At larger scales, the flying saucer metaphor comes into play and the user starts to see immersive views. Users no longer rotate the globe as an object anymore, but change their own position or direction of view. Different button allocations are needed for this case. Existing games or virtual globes such as Google Earth have tried to solve this problem by letting the user allocate specific actions to each button and stick.

Figure 4 suggests a button allocation for navigating globes, block diagrams and 2D maps. The proposed configurations for gamepads and joysticks were inspired by the button allocation used in popular video games, which should simplify the navigation for users with gaming experience. Globes have five degrees of freedom (zoom, heading, rotation around the horizontal axis, rotation around the vertical axis, and pitch angle), block diagrams only have three (zoom, heading and pitch) and 2D maps have four (zoom, heading, vertical and horizontal panning). Hence, gaming devices have to control a maximum of five different types of movement.

For gamepads, the proposed allocation uses the two standard sticks and two action buttons. The function of the left stick can be taken over by the D-pad as an option on most gamepads. A dedicated button switches between the
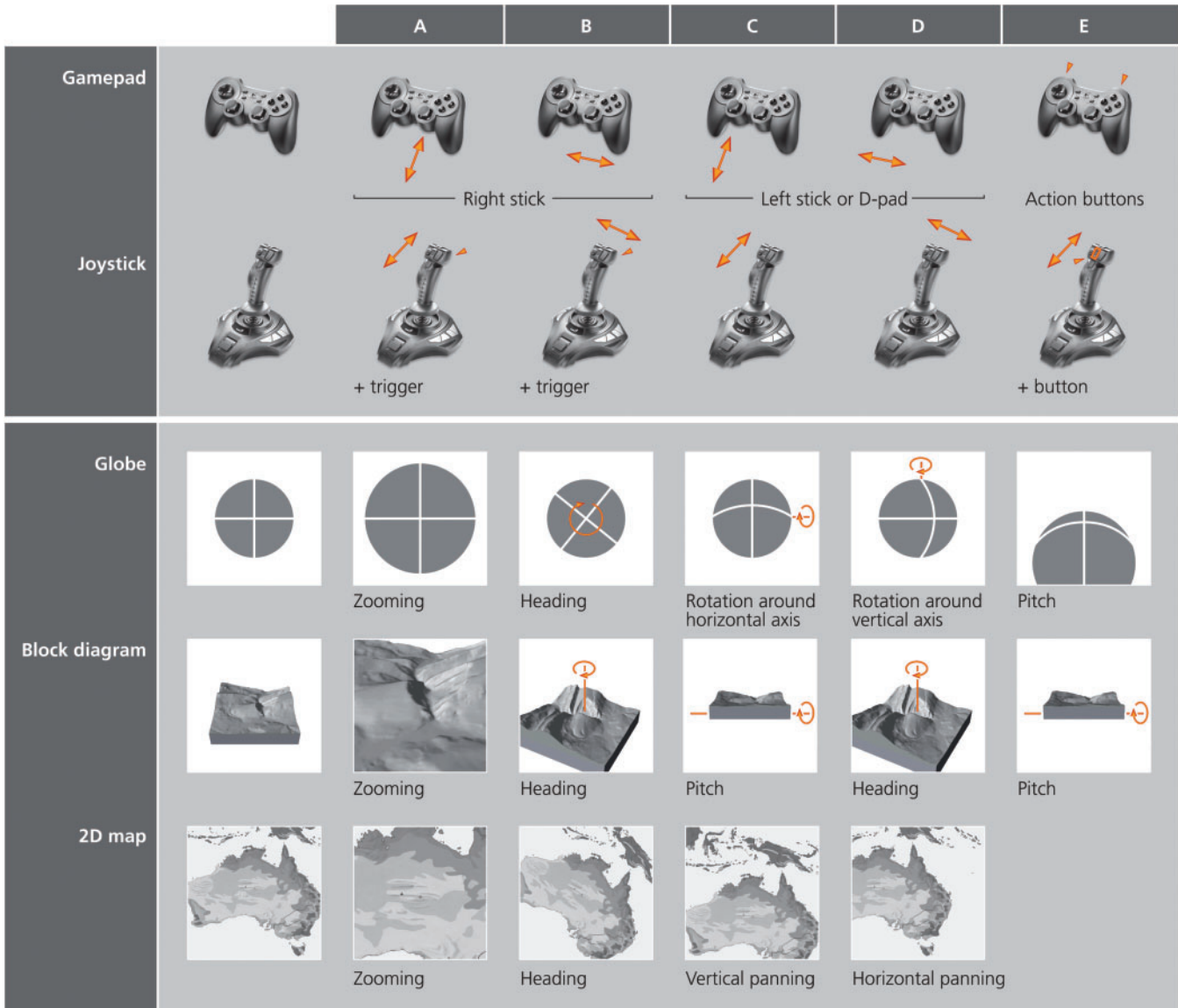
Figure 4.   Button allocation for gamepads and joysticks for navigating globes, block diagrams and 2D maps

two modes. This option is omitted here to simplify Figure 4 and the following explanations.

Joysticks are bimodal with forward–backward and left–right movements. Three additional modes are required for the five degrees of freedom for globes. Moving the stick and simultaneously holding the trigger or the thumb-button activates the additional modes.

Column A in Figure 4 shows how zooming is controlled for globes, block diagrams and 2D maps. Gamepads use a vertical movement of the right stick; joysticks use a forward–backward movement with the trigger button activated.

Column B illustrates the adjustment of the heading. For globes and 2D maps, changing the heading corresponds to a rotation around their visual centres. The heading is adjusted with gamepads by horizontally moving the right stick. Joysticks use a left–right movement with the trigger button pressed. A change to the heading of a block diagram corresponds to a rotation around the vertical axis passing through its centre. Because block diagrams have only three degrees of freedom, activating the trigger is optional.

Columns C and D illustrate the use of the left stick of a gamepad and the joystick without any button pressed. Vertical movements of both devices rotate a globe around its horizontal axis, bringing one of the poles into view. Horizontal movements rotate a globe around its vertical axis. For block diagrams, these two rotations correspond to changing the pitch and the heading. On 2D maps, the map is panned. Panning is not needed for block diagrams and globes: block diagrams generally show only a very limited section of the Earth's surface and do not need to be shifted. Globes also do not require panning: when viewing a globe at a small scale, a vertical or horizontal shift would only displace the globe away from the centre of the display window. At large scales, when the bird's eye-view metaphor is used, shifting the point of view vertically to the view direction might be counterintuitive.
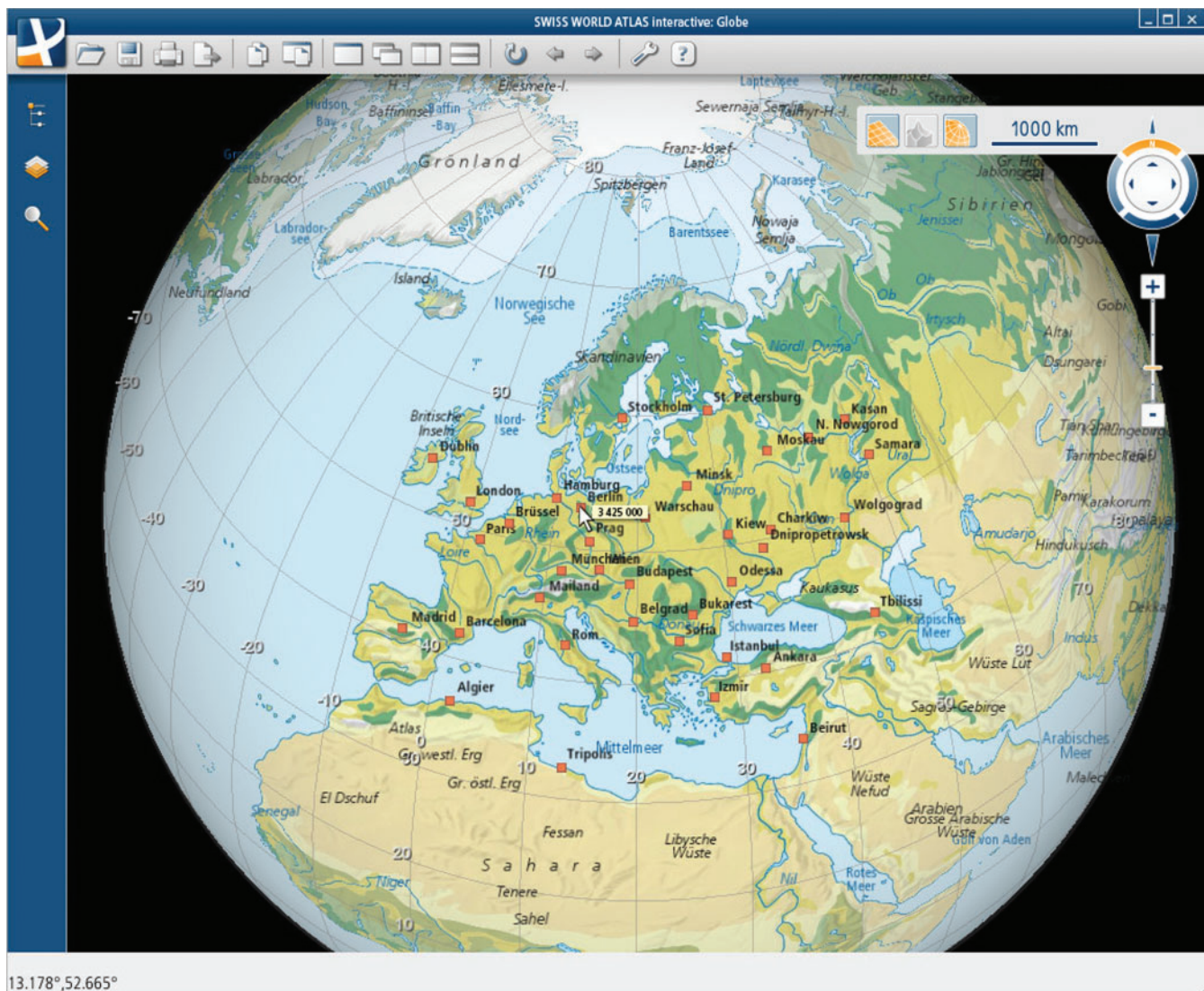
Figure 5. The globe from the *Swiss World Atlas*, draped with a topographic map, can be controlled by gamepads and joysticks (screenshot of development version)

Column E shows how the pitch angle of globes and block diagrams can be adjusted. Gamepads use two action buttons that are activated with the index fingers. Joysticks use a vertical movement with a thumb-button simultaneously pressed. For globes, this creates an immersive view at medium and large scales, lifting or lowering the horizon line.

The 'Block diagram' row in Figure 4 shows duplicate allocations for adjusting the heading and pitch angle of block diagrams. This configuration should facilitate switching between globes with five modes and block diagrams with three modes.

ENHANCING THE *SWISS WORLD ATLAS* WITH GAMEPADS AND JOYSTICKS

The trilingual *Swiss World Atlas* (Spiess, 2008) is the most used printed school atlas in Switzerland for geography education. Students between 12 and 19 years use it at the secondary school level. The first edition of the printed *Swiss World Atlas* was released at the beginning of the twentieth century. Eduard Imhof and Ernst Spiess (Imhof, 1964; Spiess, 2000) are former long-time editors. The atlas has reached a sophisticated cartographic and didactic level and won several awards (e.g. ICA Map Exhibition Award ICC97 Stockholm). The next version of the atlas will be complemented by a web-based atlas, which will include globes (Figure 5), block diagrams (Figure 6) and 2D maps, all of which will be controllable by gaming devices (*Swiss World Atlas*, 2008).

Two-dimensional maps are available for all topics covered by the atlas. The 2D maps are either complemented by a block diagram or a globe. The choice between block diagrams or globes is driven by the scale of the mapped subject. Large-scale phenomena are shown by block diagrams, as for example, the transverse valley in Figure 6. For block diagrams, pitch, heading and the zoom level can
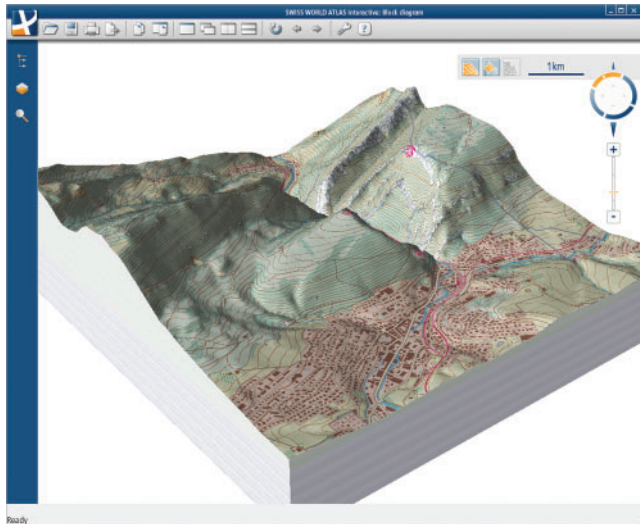
Figure 6. A block diagram from the *Swiss World Atlas* showing the transverse valley in Moutier, Switzerland, can be rotated and zoomed using game controllers (screenshot of development version)

be adjusted (Figure 4, 'Block diagram'), but the user cannot immerse into valleys or follow the terrain surface to climb a mountain peak.

Small-scale global or continental topics are visualized on 2D maps or on globes. For globes, the user can adjust the zoom level, the heading, the rotation around the horizontal and vertical axes, and the pitch angle (Figure 4, 'Globe'). The flying saucer metaphor is used to let the globe roll under the observer, which creates a captivating flight effect, especially when the pitch angle is inclined.

It is hoped that the digital edition of the atlas will overcome the problems that have hindered the widespread adoption of geospatial technologies in education. The main problems with GIS in schools are (Bednarz and Bednarz, 2008: p. 250; Bunch *et al.*, 2008: pp. 228–229; Milson and Roberts, 2008: p. 40):

- the complexity of GIS software (students who receive lessons with geospatial technology are, in many cases, preoccupied with learning the software and the subject itself often gets lost);
- the unavailability of pre-processed data for GIS;
- the unequal access to hardware and software;
- teacher's lack of familiarity with GIS for instruction and weak technical and institutional support;
- excessive demands on teachers' time;
- pedagogic issues related to the curriculum (teachers find it difficult to identify the role of GIS in the curriculum).

A series of technical and design measures have been taken to tackle these problems in the digital edition of the *Swiss World Atlas*. The atlas is not a complex GIS, but provides ready-to-use maps that correspond to the curriculum, and an interface that is easy to use.

Owing to the very wide range of personal computer equipment available in schools, the digital *Swiss World Atlas* must be platform independent. The client software was therefore developed in the Java programming language, which is available on all major operating systems. The application logic and the geographical data are distributed

using Java Web Start, which allows the students to launch the atlas by clicking on a link in a web page (Sun Microsystems, 2005). An installation procedure is not necessary, as Java Web Start automatically ensures that the most recent version of the application is downloaded. All spatial data are streamed 'on the fly' from a server. Most schools in Switzerland have a broadband Internet connection, which is needed for this approach.

Authors of interactive atlases are confronted nowadays with users expecting Google Earth-like representations and functionality. Despite its immense popularity, Google Earth was not the first virtual globe (Riedl, 2006). An earlier, but less well-known example is the NASA World Wind application (NASA, 2006; Bell *et al.*, 2007). It is a free, open source virtual globe that today is jointly developed by NASA and an open source community. Its functionality and data overlays are very similar to Google Earth, but World Wind has never reached the same popularity and diffusion. Its open source property and its relatively modest requirements in computer hardware, however, make it an attractive base for the development of a customized globe. The virtual globe of the *Swiss World Atlas* was implemented using the Java branch of the World Wind project (NASA, 2008).

All functions of the atlas can be controlled by a traditional mouse or a keyboard. Supplemental support for gaming devices was added using the jinput library, which manages the communication with a wide variety of game controllers (Davison, 2007). It was initiated by the Game Technology Group at Sun Microsystems (java.net, 2007a) and is also an open source library in Java. The jinput library takes care of the differing communication protocols or hardware configurations and provides applications with uniform commands when the user presses a button or moves a stick. After connecting a gaming device, the user of the atlas can seamlessly switch between the mouse and the device, without the need to change any software settings.

To combine the NASA World Wind library and the jinput library, an intermediate glue module was developed in Java. This glue module receives commands from the game controller and converts them to movements of the globe by calling the appropriate functionality of the World Wind library. This is where the button allocations outlined in the previous section are applied. A later version of the atlas application could offer a dedicated graphical interface that would allow the user to personalize the button allocation. The glue module would then dynamically interpret the new allocation scheme.

For rendering the globe, NASA World Wind uses OpenGL (Open Graphics Library). OpenGL is a standard specification defining a cross-language cross-platform interface for writing applications that produce 2D and 3D computer graphics (Segal and Akeley, 2004; OpenGL.org, 2008; Shreiner *et al.*, 2008). It can be used to draw complex three-dimensional scenes from simple primitives and is widely used in scientific visualisation, virtual reality, CAD and video games.

Three-dimensional block diagrams in the *Swiss World Atlas* are also rendered with OpenGL. As OpenGL is a specification for the C programming language, and not for Java, the Java OpenGL (JOGL) library was used. JOGL is a wrapper library that allows OpenGL to be accessed with the

Java programming language. It is currently being developed by the Game Technology Group at Sun Microsystems (java.net, 2007b).

OUTLOOK

The final version of the web-based *Swiss World Atlas* will be released in 2010. It will be interesting to observe how teachers and students use gaming devices to navigate in the atlas. Indeed, teachers, together with developers, interface designers, cartographers and experts in didactics, will have to think about the best way to integrate gaming devices in the curriculum. Can a game-enhanced atlas be used efficiently in the classroom to enhance instruction and learning, or is it just a toy unable to provide additional value for education? Kerski (2008: p. 132) argues that virtual globes can be so captivating to many students that they have problems concentrating on the tasks assigned. He calls globe software a 'source of temptation […] literally in front of their faces'. Hence, educators will have to think about appropriate assignments and must find a balance between tightly supervised and entirely serendipitous student activities.

A possible obstacle to the diffusion of atlases enhanced by gaming devices might be hardware related. Gamepads are cheap, but most schools do not currently own such equipment. The variety of gaming devices might also hinder their diffusion since they do not have a standardized number of buttons and sticks, and vary in functionality and layout. This may lead to problems from a developer's point of view, as the software application must be prepared for this multitude of configurations, and it could also hamper their adoption, since a user manual or a help function cannot cover every existing type of gaming device.

CONCLUSION

Globes, block diagrams and 2D maps that are navigable with gamepads and joysticks offer fascinating new means of interaction and use cases. The integration of gamepads and joysticks makes sense for school atlases, because most students are already experts at using such devices for navigation in virtual environments.

One of the most important insights learned from this project was that cartographers must be familiar with the steering and controlling methods commonly used in games, as these concepts will have to be transferred to maps and globes. One example is the graphical user interface for the selection of maps or map overlays, which must have much larger buttons and menus to accommodate navigation with gaming devices. Video game designers have designed such interfaces and developed methods for usability tests (Isbister and Schaffer, 2008). These specialized interfaces can serve as a source for the design of atlases. Because of the coexistence of game controllers and the traditional keyboard and mouse combination, however, designing a graphical user interface for all types of input devices is a demanding task. Another area where cartographers should draw inspiration from video games is interaction with map features. At this time, it is not clear what is the best method

of selecting a symbol on a globe to query its attributes with a gamepad or a joystick. In addition, simple methods for marking an area of interest on a globe or block diagram should be available that would allow a teacher to direct the students' attention to a selected area. Currently, we cannot provide any well thought-out advice on how to best design and implement such functionality for gaming equipment used in school atlases. This is an area necessitating further research, possibly based on user surveys.

A small survey with an early prototype found that even inexperienced users quickly familiarize themselves with gamepads and are able to turn their attention from the device to the atlas. They navigate efficiently in space after a short period of time. The authors are therefore confident that teachers and students will adopt game-enhanced atlases.

BIOGRAPHICAL NOTES

This paper is the result of a collaborative effort of various members of the Institute of Cartography, ETH Zürich. Adrian Weber (MSc in Geomatics) was a programmer for the *Swiss World Atlas*, the official Swiss school atlas. He, among other things, enhanced virtual globes and block diagrams with game controllers. Bernhard Jenny is a PhD candidate at the Institute of Cartography. Matthias Wanner is a geomatics student at ETH Zürich. He implemented a game-enhanced globe for his Bachelor of Science thesis. Juliane Cron (BSc in Cartography) and Philipp Marty (MSc in Geography) work as editors and cartographers for the *Swiss World Atlas*. They contributed to the development of game-enhanced globes and block diagrams. Lorenz Hurni (Professor and Chair of the Institute of Cartography, ETH Zürich) is the new Editor-in-Chief of the *Swiss World Atlas*.

REFERENCES

Bednarz, S. W. and Bednarz, R. S. (2008). 'Spatial thinking – the key to success in using geospatial technologies in the social studies classroom', in **Digital Geography: Geospatial Technologies in the Social Studies Classroom**, ed. by Milson, A. J. and Alibrandi, M., pp. 249–270, Information Age Publishing, Charlotte, NC.

Bell, D. G., Kuehnel, F., Maxwell, C., Kim, R., Kasraie, K., Gaskins, T., Hogan, P. and Coughlan, J. (2007). 'NASA World Wind: opensource GIS for mission operations', in **2007 IEEE Aerospace Conference**, pp. 1–9, Big Sky, MT, Mar 3–10.

Bunch, R., Nelson, E., Lloyd, R. E., Kane, M. and Tricot, T. (2008). 'Instructional geographic information science', in **Digital Geography: Geospatial Technologies in the Social Studies Classroom**, ed. by Milson, A. J. and Alibrandi, M., pp. 227–245, Information Age Publishing, Charlotte, NC.

Davison, A. (2007). **Pro Java 6 3D Game Development: Java 3D, JOGL, JInput and JOAL APIs**, Apress, Berkeley, CA.

Fuhrmann, S. and MacEachren, A. M. (1999). 'Navigating desktop GeoVirtual environments', in **IEEE Symposium on Information visualization 1999**, pp. 11–14, San Francisco, CA, Oct 23–28.

Google (2005). Google Earth, http://earth.google.com (accessed 16 December 2008).

Google (2006). Google Releases 2006 Google Earth Election Guide, http://www.google.com/press/pressrel/earth_election_guide.html (accessed 16 December 2008).

Green, D. R. and Mouatt, J. (2008). 'The digital globe – using Google Earth for virtual fieldtrips of coastal environments', in **Digital Geography: Geospatial Technologies in the Social Studies Classroom**, ed. by Milson, A. J. and Alibrandi, M., pp. 147–165, Information Age Publishing, Charlotte, NC.

Imhof, E. (1964). 'The Swiss Mittelschulatlas in new form', in **International Yearbook of Cartography**, ed. by Imhof, E., Vol. 4, pp. 69–86, Bertelsmann, Gütersloh.

Isbister, K. and Schaffer, N. (2008). **Game Usability: Advancing the Player Experience**, Morgan Kaufmann, San Francisco, CA.

java.net (2007a). jinput Project Home, http://jinput.dev.java.net (accessed 16 December 2008).

java.net (2007b). JOGL API Project, http://jogl.dev.java.net (accessed 16 December 2008).

Kerski, J. J. (2008). 'The world at the student's fingertips – Internet-based GIS education opportunities', in **Digital Geography: Geospatial Technologies in the Social Studies Classroom**, ed. by Milson, A. J. and Alibrandi, M., pp. 119–134, Information Age Publishing, Charlotte, NC.

Midtbø, T. and Nordvik, T. (2007). 'Effects of animations in zooming and panning operations on Web maps: a web-based experiment', **Cartographic Journal**, 44, pp. 292–303.

Milson, A. J. and Roberts, J. A. (2008). 'The status of geospatial technologies in U.S. high school geography standards', in **Digital Geography: Geospatial Technologies in the Social Studies Classroom**, ed. by Milson, A. J. and Alibrandi, M., pp. 39–59, Information Age Publishing, Charlotte, NC.

Mitchell, A. and Savill-Smith, C. (2004). **The Use of Computer and Video Games for Learning: A Review of the Literature**, Learning and Skills Development Agency, London.

NASA (2006). World Wind, ed. by Kim, R., National Aeronautics and Space Administration, http://worldwind.arc.nasa.gov (accessed 16 December 2008).

NASA (2008). NASA World Wind Java SDK, ed. by Kim, R., National Aeronautics and Space Administration, http://worldwind.arc.nasa.gov/java/ (accessed 16 December 2008).

OpenGL.org (2008). OpenGL – the industry's foundation for high performance graphics, http://www.opengl.org (accessed 16 December 2008).

Prensky, M. (2001). **Digital Game-based Learning**, McGraw-Hill, New York.

Riedl, A. (2006). 'Digital globes', in **Multimedia Cartography**, 2nd ed., ed. by Cartwright, W., Peterson, M. P. and Gartner G., pp. 255–266, Springer, Berlin Heidelberg.

Schöning, J., Hecht, B., Raubal, M., Krüger, A., Marsh, M., and Rohs, M. (2008). 'Improving interaction with virtual globes through spatial thinking: helping users ask ''why?''', in **13th International Conference on Intelligent User Interfaces (IUI '08)**, pp. 129–138, Gran Canaria, Jan 13–16.

Schultz, R. B., Kerski, J. J. and Patterson, T. C. (2008). 'The use of virtual globes as a spatial teaching tool with suggestions for metadata standards', **Journal of Geography**, 107, pp. 27–34.

Segal, M. and Akeley, K. (2004). The OpenGL graphics system: a specification, http://www.opengl.org/documentation/specs/version2.0/glspec20.pdf (accessed 16 December 2008).

Shreiner, D., Woo, M., Neider, J. (2008). **OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 2.1**, 6th ed., Addison-Wesley, Upper Saddle River, NJ.

Spiess, E. (2000). 'Die Redaktionsarbeiten für den Schweizer Weltatlas', **Vermessung, Photogrammetrie, Kulturtechnik**, 10, pp. 607–609.

Spiess, E. (2008). **Schweizer Weltatlas**, Lehrmittelverlag des Kantons Zürich, Zürich.

Sun Microsystems (2005). Java™ Web Start overview – White Paper, http://java.sun.com/developer/technicalArticles/WebServices/JWS_2/JWS_White_Paper.pdf (accessed 16 December 2008).

Swiss World Atlas (2008). *Swiss World Atlas*, Institute of Cartography, ETH Zürich, Zürich, http://www.swissworldatlas.ch (accessed 16 December 2008).