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REFEREED PAPER

Map Design for a Multi-Publishing Framework – Case MenoMaps in Nuuksio National Park

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The paper describes the map design process of the MenoMaps project, which aims to create new kinds of maps for supporting outdoor leisure activities, and to carry out research on the utilisation of multi-publishing in a cartographic context. The idea behind a multi-publishing service is that the service is able to deliver different kinds of outdoor maps through a number of channels and at varying scales and designs from a single data core. The data core utilizes integrated data sources, including the Finnish topographic and map databases of the National Land Survey of Finland, as well as datasets from the Nuuksio National Park test environment of the Finnish Geodetic Institute, including high-resolution orthophotos and digital terrain models based on airborne laser scanning (LIDAR). In contrast to traditional national park cartography, the multi-publishing framework sets new challenges for the map design. The paper summarizes the design process and gives examples of the in-house developed map design for so-called Topographic, Relief, Forest, Orthophoto and Winter maps. It concludes by discussing the design challenges of the multi-publishing framework.

Ce papier décrit le processus de conception de cartes du projet MenoMaps dont les objectifs sont de 1/ créer de nouveaux types de cartes pour permettent les activités de loisirs en extérieur et 2/ de poursuivre des recherches sur l'utilisation de publications multiple dans un contexte cartographique. L'idée sous-jacente au service de publication multiple est que le service soit capable de produire différents types de cartes à travers différents canaux de diffusion, à différentes échelles, selon un design différent et ce à partir d'un noyau de données unique. Ce noyau de données est basé sur l'intégration de sources de données dont les cartes et bases de données du National Land Survey de Finlande, ainsi que les données environnementales du Parc National Nuukio de l'Institut de Géodésie de Finlande, en particulier des ortho-photographies à haute résolution et un modèle numérique de terrain basé sur des relevés LIDAR. En comparaison avec la cartographie traditionnelle des parcs nationaux, la structure de publication multiple apporte des nouveaux challenges dans la conception cartographique. Le papier résume le processus de conception et donne des exemples de conception de cartes dites topographiques, de relief, des Forets, Ortho et d'Hivers. Nous concluons en exposant les challenges de la conception dans la cadre d'une structure de publication multiple.

Keywords: map design, context-aware applications, maps/data production

BACKGROUND AND OBJECTIVES

The challenge of the current publishing industry is to take advantage of technological innovations affecting daily life. One such innovation is multi-publishing, where the purpose is to publish the same information using different media (for example, Zedler and Ramadan, 1997; Lehto *et al.*, 2001). The idea behind a multi-publishing service supporting outdoor leisure activities is to deliver different kinds of outdoor maps through a number of publishing channels from a single data and design core (Figure 1). Thus, such maps as web maps, printed maps and maps on smartphones are all based on the same data core (Sarjakoski *et al.*, 2010), and the design drivers (Flink, 2009) are all taken from the shared map design core.

In comparison to traditional map products for national park visitors, the multi-publishing framework and context-awareness set new challenges for the map design process. While experiments using the same data from national parks for dual use, such as print maps at two levels of scale, do exist (e.g., Patterson, 2007), experiences with using a wide spectrum of publishing channels and scale levels are few. The properties of the channels may differ fundamentally in terms of interactivity, colour mixing (additive/subtractive) and gamut, spatial extent and resolution, as well as in terms of the typical viewing distance between the user and the

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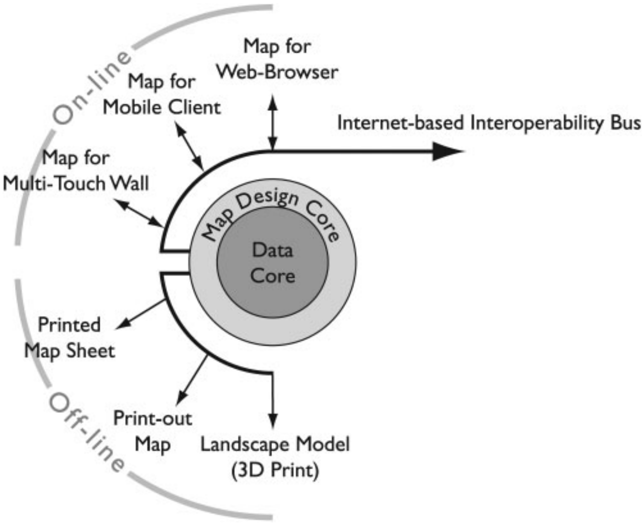

Figure 1. Schematic illustration of the multi-publishing framework in a cartographic context

media. Therefore, adaptation is needed to fit the contents from one channel into another channel (Zedler and Ramadan, 1997). Furthermore, hikers' use contexts vary and users want to look at maps adapted to their current needs (Nivala *et al.*, 2009). They also require a cartographic design which provides intuitive representations for individual user groups.

Conventional topographic map design is closely related to technical drawing, combining the purposes of data storage and presentation, and is typically aimed at experienced map users. This is supported by the results of the NACIS Map Design Survey, in which more than half of the respondents felt that science dominates art in the current cartography profession (Patterson *et al.*, 2007). However, it has been suggested that national park maps should be directed at inexperienced map readers (Patterson, 2002), because even the basic contents of the topographic maps can be difficult to understand for people outside of the cartographic community (Sarjakoski and Nivala, 2005).

Nowadays, personal navigation applications on mobile devices and other web-based applications mainly focus on cities or urban areas. In rural areas, where outdoor leisure activities primarily take place, personal navigation solutions are, for the most part, lacking. The study for the 'multi-publishing in supporting outdoor leisure activities' (MenoMaps) project has been carried out to find innovative alternatives to the current Nuuksio National Park maps (Figure 2) by investigating novel methods for presenting outdoor map data sets for varying user needs and publishing channels. The aim of the map design process for the MenoMaps service was to create a map series of Nuuksio National Park for different use contexts, scale levels and publishing channels sharing a uniform cartographic design (Flink, 2009). Therefore, a holistic design was simultaneously needed for all of the scale levels, use contexts and channels, and all of the design decisions were subordinated to the possibilities and restrictions of the multi-publishing framework.

In the following section, the paper describes the design of maps produced for the MenoMaps project and raises the design issues related to multi-publishing in a cartographic context. Issues specifically related to the data integration and generalisation of the MenoMaps' data core (Sarjakoski *et al.*, 2010), as well as experimental visualisation methods, such as rapid prototyping (Schwarzbach *et al.*, 2009) and cartographic 3D visualisation (Kettunen *et al.*, 2009), have been presented elsewhere.

TEST ENVIRONMENT AND METHODS

In the MenoMaps project, the data sets from the Finnish Geodetic Institute's (FGI) Nuuksio test environment for ubiquitous geospatial services (Sarjakoski *et al.*, 2007) were utilised. The data core for the multi-publishing service includes the FGI's LIDAR point cloud, LIDAR DEMs with a resolution of 1–10 m, real- and false-colour orthophotos with a resolution of 0.2 m, and a GPS-based trail database. In addition, we utilized topographical data sets from the National Land Survey of Finland at the scales of 1 : 25 000 and 1 : 100 000.

All of the maps designed for the MenoMaps project consisted of information at two levels: (1) static background maps and (2) dynamic thematic contents, including hiking routes and point-of-interest (POI) data. We stored all

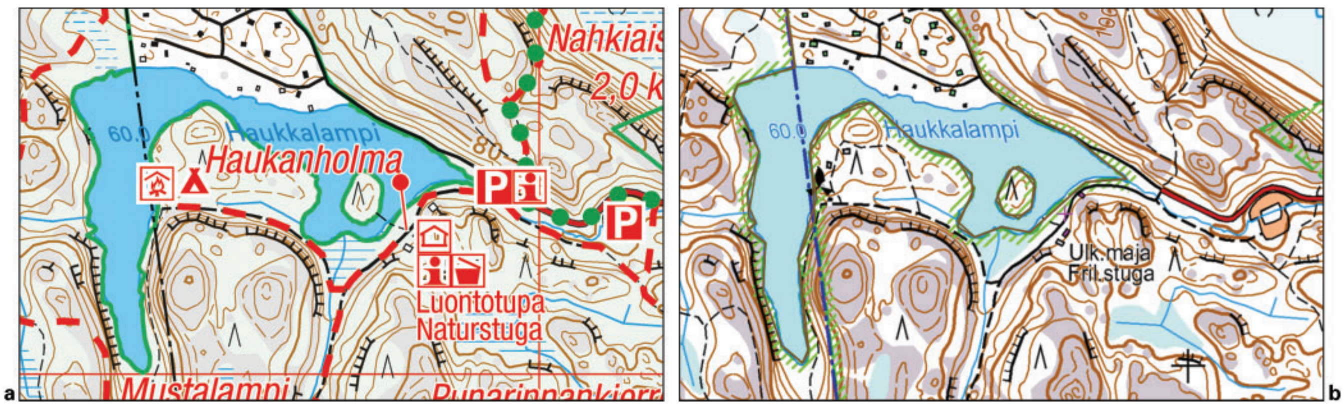

Figure 2. The maps available on the market for hikers in Nuuksio National Park: (a) the Nuuksio-Luukkaa Outdoor Map 1 : 20 000 (©Karttakeskus, licence L8658/10), (b) the outdoor map from www.retkikartta.fi web-service (©National Land Survey of Finland, license 53/MML/10 and National Board of Forestry)

background maps as raster data on the server, while the overlaid thematic content was available as vector data. The design of the vector data has been developed to fit together with the background maps, but we do not focus on it further in this paper.

In the design core, the use of six scale levels for the web maps (design scales 1 : 1500–1 : 48 000) was fixed to be able to cover the full visualisation potential of the available data sets, to satisfy the expected user needs of the national park visitors and to serve as the starting point for adapting the design to the other publishing channels. Furthermore, related to the use contexts (generic, hiking, biking and skiing), we created the design for several map types, which we named 'the Topographic map', 'the Relief map', 'the Forest map', 'the Orthophoto maps' and 'the Winter map'. The map design core also contained the methods for adapting the contents to different publishing channels while preserving the graphical and cartographical quality of the maps. The channels through which the maps were delivered were an LCD monitor, a mobile device (Apple iPhone 3GS) and printed media.

We divided the cartographic process for the MenoMaps' multi-publishing purposes into data-processing, map-composition and image-processing steps. The data-processing step included, for example, the extraction of map data from the LIDAR and image data using Terrasolid TerraScan and TerraPhoto software, as well as data integration and generalisation operations with ESRI ArcGIS 9.3.1. In the map-composition step, we defined design principles of the MenoMaps service and created symbol, colour and typographic design with ArcGIS. Finally, in the image-processing step in Adobe Photoshop CS4, we rasterized the graphical layers resulting from the previous step with anti-aliasing for screen maps (Jenny *et al.*, 2008) and without anti-aliasing for the print media. Furthermore, design modifications for specific map elements, map composition from the graphical layers using varying blending modes and opacities as well as colour-system conversions were done. The details of the map design are described in the following section.

Map design

One of the requirements of the map series in a multi-publishing framework is to share a uniform cartographic design for all the maps delivered by the map service. To achieve this, we consistently used several design methods throughout all of the map types.

The symbol and label design aimed at a modernistic map style and took advantage of the current possibilities in image processing. For hydrographic features, we used vignetting and shadowing to separate them clearly from other terrain features. Contours were generated from the LIDAR DEM (Oksanen and Sarjakoski, 2005), generalized and labelled automatically for all design scales. All labels utilize a sans serif typeface. The typographic separation of labels was done by using italics and non-italics types, as well as a clear type size hierarchy. We put additional emphasis on the cartographic masking of the labels, in which the labels mask only the underlying graphical layers having the same colour as the type.

We did the principal colour design of the maps for the current 'web-standard' sRGB colour space (Stokes *et al.*, 1996; Jenny *et al.*, 2008). For printed maps, we converted sRGB colours to the CMYK colour space for offset printing on high-quality coated paper by using a perceptual rendering intent. Furthermore, we paid attention to the existence of colours in RGB and CMYK gamuts to prevent critical colour shifts when using different publishing channels.

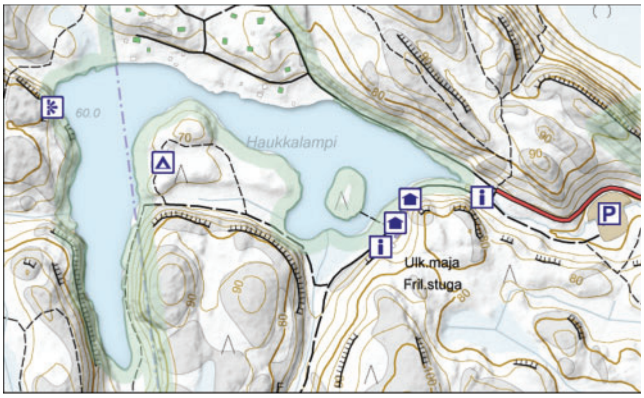

Figure 3. Example of the Topographic map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

As a visual flavour, we created a 3D impression of the terrain by adding relief shading (azimuth NW, vertical angle 45°) to the maps. The use of relief shading has been suggested in earlier usability tests of national park maps (Sarjakoski and Nivala, 2005). We resolved the problem of a grey tone for flat areas in analytical hill shading (Imhof, 1982; Jenny *et al.*, 2001) by lightening the mid-greys and increasing the contrast of the result. Finally, we added the hill shading to the top of the map composition by using a multiply blending mode.

In addition to the principle design decisions, which were applied to the whole map series of MenoMaps, we needed to include special settings related to the different map types in order to support their use within different contexts. These specific design methods are highlighted in the following paragraphs together with a sample illustration for each map.

The Topographic map (Figure 3) represents features important for outdoor activities in general and serves as the basis for maps designed for other use-situation contexts.

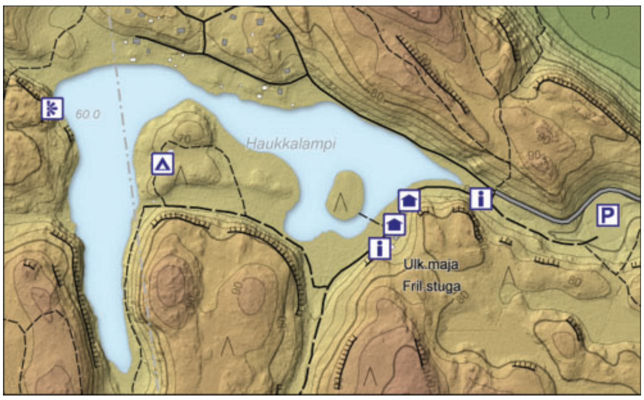

Figure 4. Example of the Relief map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

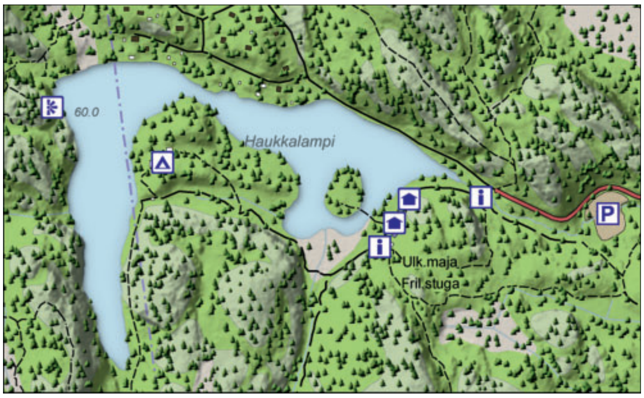

Figure 5. Example of the Forest map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

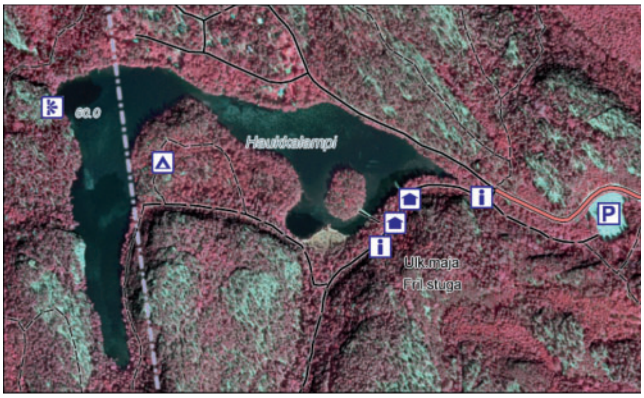

Figure 7. Example of the infra-red Orthophoto map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

The graphical layers in the Topographic map are: (1) land-cover and terrain features; (2) hydrography; (3) contours; (4) roads, transmission networks and administrative boundaries; (5) the boundaries of conservation areas; (6) labels; (7) relief shading; and (8) buildings. In the colour design, we used saturated colours sparingly to introduce the visual hierarchy for the map.

The Relief map (Figure 4) represents the terrain features relevant especially for cycling. Additionally, the Relief map indicates of rough trail sections, which is also of interest for hikers. Owing to the topography of Nuuksio National Park, as well as the extent and the chosen scale range of the maps from the MenoMaps service, we found the equidistant classification and the standard form of the modified spectral colour scale (Imhof, 1982) together with the relief shading to be suitable for classifying and representing the terrain. We emphasized the visual hierarchy of the map elements using saturated colours for the relief and a grey-scale representation for other features. Additional masking of labels was done by adding a white halo.

The Forest map (Figure 5) aims to provide an intuitive view of the national park by utilizing tree symbols to visualize the forest. The location and type of the trees were detected automatically from the Nuuksio test environment's LIDAR data and CIR images (Schwarzbach *et al.*, 2010). For the Forest maps, we have changed the colours of the map background and several areal terrain features in order to integrate the trees with the map background. We have masked trees close to other topographic features, such as roads, paths and buildings, as well as trees superimposed by labels, to ensure a better readability for the map. We produced a 3D impression by means of the drawing order of the pictorial tree symbols and the order of the graphical layers in the map-composition process. Furthermore, we added a light-and-shadow effect to the tree symbols, which corresponds to the light direction of the relief shading.

The Orthophoto maps (Figures 6 and 7) represent the landscape without any of the abstract symbolisation used in topographical maps. In addition to orthophotos, only man-made networks and labels were visualized from the MenoMaps data core. We added a white halo to labels to separate them from the graphically loaded background. To make visible the details of the relief relevant for outdoor activities, we added relief shading to the orthophotos. The azimuth of the relief shading appeared to be critical, and the only way to achieve a 3D impression on the orthophoto was to set the lightning direction of the DEM in the SE, which is roughly the same as the direction of the sunlight during the flight mission. However, the unconventional direction of light introduced risk of visual relief inversion (Imhof, 1982).

The Winter map (Figure 8) aims at serving skiers. Features relevant only to summer activities, such as water networks and cultivated areas, are excluded from the

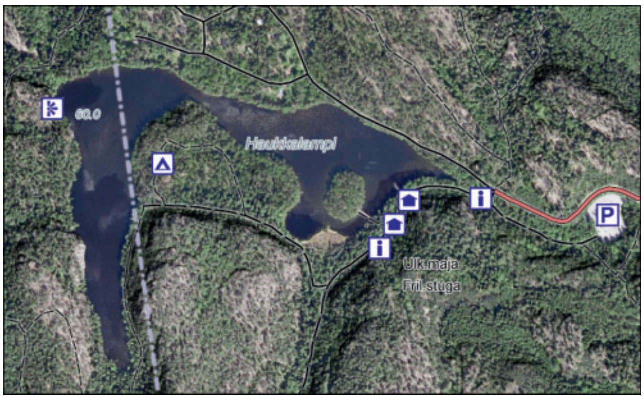

Figure 6. Example of the Orthophoto map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

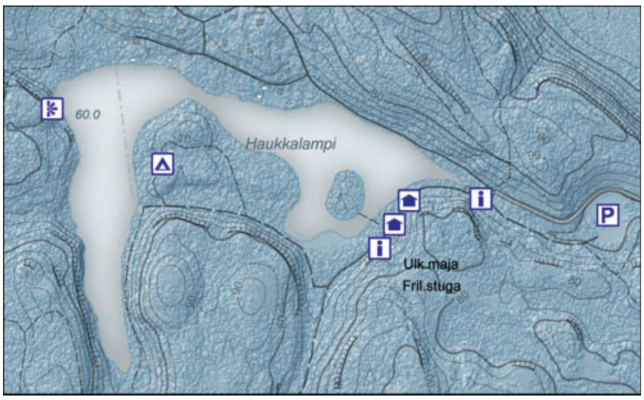

Figure 8. Example of the Winter map created for the MenoMaps service at the design scale of 1 : 6000 for a screen

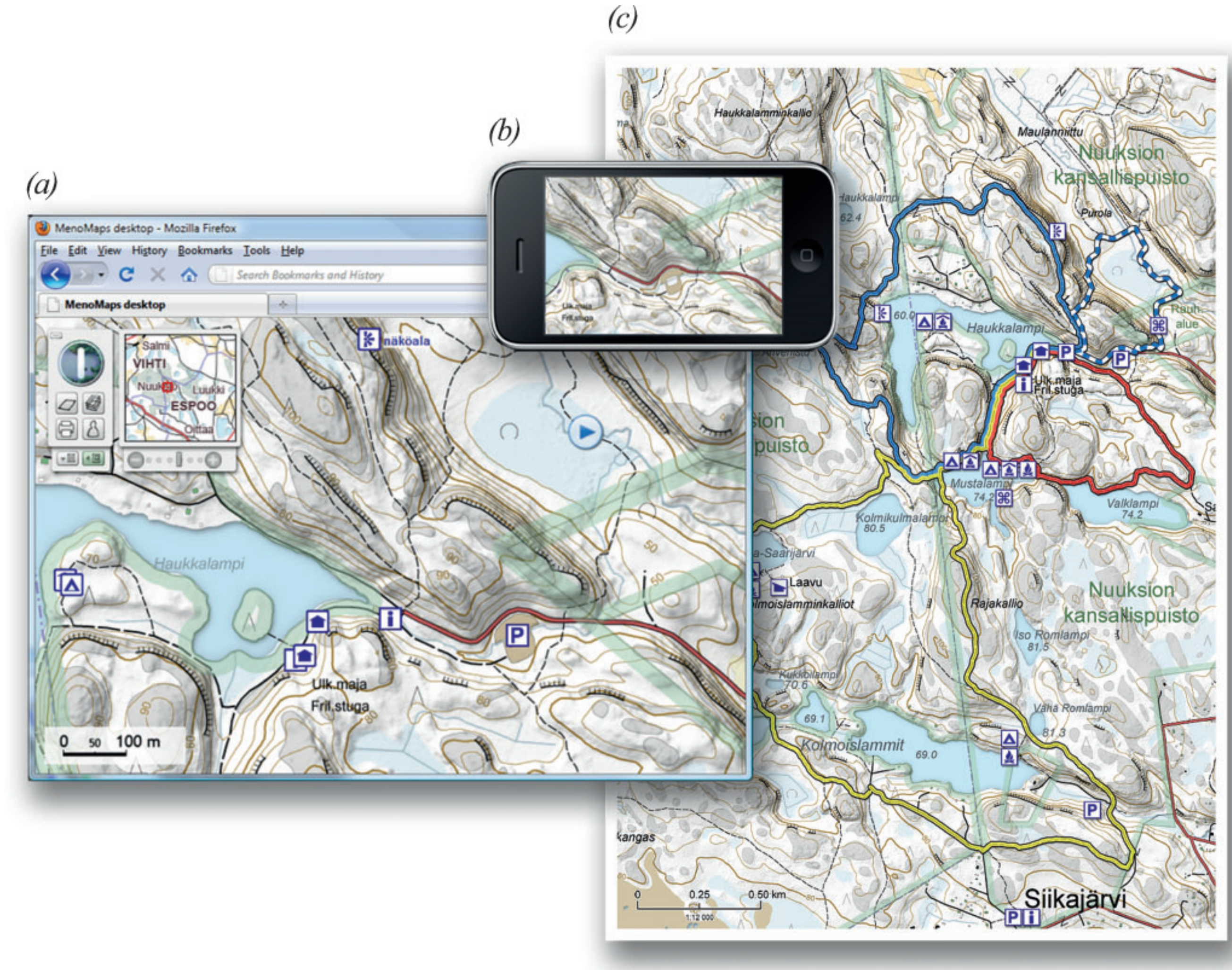

Figure 9. Examples of the MenoMaps Topographic map in three publishing channels: (a) web map, (b) mobile map, (c) printed map

graphical layers. We derived the winter map as a composite of the following features: (1) a relief-shaded digital surface model, including all above ground objects, in which open areas were smoothed to give an impression of snow coverage; (2) a relief-shaded DEM; (3) a hydrographic layer with a light bluish tone and vignetting, together with an inner shadow, to give an impression of ice coverage; and (4) the transmission network, contours and buildings in grey tones.

RESULTS AND DISCUSSION

We utilized the different maps resulting from the design process in the different publishing channels including the web map, the mobile map and the printed maps (Figure 9). We designed and produced the Topographic map, the Relief map and the Orthophoto maps for all screen map design scales 1 : 1500–1 : 48 000, while we produced the more experimental Forest map only for scales 1 : 6000 and 1 : 12 000 and the Winter map for the scale 1 : 6000. The results from the usability study of the MenoMaps maps are presented by Flink *et al.* (2011). The challenge in designing maps for a context-aware multi-publishing framework is to adapt the design to a number of publishing channels and, at the same time, take into account the different needs of the users. The channels differ fundamentally in their levels of interactivity and dynamics, as well as in their colour systems and resolutions. Simultaneously, the visual coherence of the maps within the multi-publishing service as a whole should be preserved. In the following section, we discuss the results of the design process regarding these issues.

Interactivity and dynamics

Online channels with a high level of interactivity offer the means for delivering use-context aware maps tailored for specific outdoor activities. Compared to offline publishing channels, adaptation to different use-contexts is easy in the online channels and the dynamics of the media offer numerous possibilities to publish experimental map types. For example, the Orthophoto maps formerly thought of as unsuitable for outdoor activities (Patterson, 2002) can hardly be seen as an independent printed map product. Rather, they should now be seen as a valuable additional information layer within an interactive map service.

Furthermore, updating the maps for on-line publishing channels is very cost-efficient, whereas doing it for offline media is expensive. The combination of context-awareness and a multi-publishing framework easily results in a large amount of maps, and the workloads for the updating processes may become unexpectedly large. At the very least, distinct updating strategies should be defined for each publishing channel, which contradicts the idea behind a multi-publishing service.

Splitting the MenoMaps maps into a static background and dynamic thematic layers appeared to be a good solution from the perspective of cartographic quality and project management. Even though in the MenoMaps project, we chose to separate the static and dynamic layers at the point between the background maps and the route/POI information, the separation could also have been done differently. For example, it is possible to set labelling on a separate dynamic layer to allow for real-time placement and rotation of the labels at the cost of less-optimal cartographic quality for the real-time masking of the underlying features. Compared with a real-time data integration and generalisation approach (GiMoDig, 2004), the static background map approach offers several advantages. First, a higher cartographic quality can be achieved when considering the multi-publishing framework. Second, the use of raster data by a number of clients is flexible and it is easy to preserve a consistent map design in different channels. Third, project management becomes easier when different teams from the research group have clearly separated responsibilities. Finally, the raster approach offers the possibility to experiment with 3D cartographic representations (Kettunen *et al.*, 2009) which are currently not supported by the map client software.

Colour

When considering colour design, the multi-publishing framework still suffers from the well-known differences between the colour models used for different media (e.g. Brown, 1993). However, colour conversions from one model to another have become easier, since the sRGB colour space has already become a web-standard (Stokes *et al.*, 1996; Jenny *et al.*, 2008), a number of manufacturers have added native support for sRGB to their monitors and the diffusion of colour management systems in home use and print houses is continuing (ICC, 2004). Despite the use of a colour management system, the challenge of different gamuts in RGB and CMYK colour spaces, as well as the spectral resolution of the publishing channels, should be taken into account in the map colour design. Furthermore, the situations in which the channels are used are different and, for example, the amount of predominant lightning is various, which requires the fine-tuning of colour for different publishing channels.

Resolution

Another fundamental challenge in a multi-publishing approach is the resolution differences of the publishing channels. The optimal acuity of the human eye can be as high as 50 cycles per degree (Russ, 2007), resulting in a minimum line width of 0.1 mm for paper maps at a typical reading distance of 0.3 m (Imhof, 1982). On this basis, much of the acuity of the human eye is not used when maps are show on LCD monitors having a typical resolution of 72–144 ppi (Jenny *et al.*, 2008) and a median viewing distance of 0.68 m (Charness *et al.*, 2008). This underuse of the acuity of the human eye has two implications. First, the edges of the features on the screen appear jagged if no anti-aliasing is used (Jenny *et al.*, 2008). Second, the map scale for the monitor should be 3–4 times as large as the scale used with paper media if the information density of the map is to be preserved. From the multi-publishing perspective, this means that symbols and labels have to be designed separately for publishing channels having different resolutions, and the use of anti-aliasing in the rasterisation of the layers must be applied channel-wise as well. On the other hand, the resolution of the current smartphones, which has a typical viewing distance of less than 30 cm (Hasegawa *et al.*, 2007), makes the design gap between screen maps for LCD monitors and mobile clients smaller (Sarjakoski *et al.*, 2010). In the future, the design gap between print media and high-resolution electronic media should diminish in terms of symbolisation because smartphone screens having a resolution of >300 ppi are already on the market (Apple, 2010) and e-paper devices are actively being developed.

CONCLUSIONS AND FUTURE WORK

The challenge of map design for a context-aware multi-publishing framework is to adapt the design to a number of publishing channels and, at the same time, take into account the different needs of the users. Simultaneously, the visual coherence of the maps in the multi-publishing service as a whole should be preserved. Therefore, process of designing modern maps for outdoor activities no longer involves designing one map at a specific scale for one channel, but, rather, designing a series of intuitive maps for different use situations, at a number of scale levels and for a number of publishing channels.

The map design process in the MenoMaps project confirmed the fact that the multi-publishing framework for a map service emphasizes the role of the art in cartography as well as the specific essence of maps compared with general graphical illustrations and pictures. While art in cartography is often discussed in the sense of aesthetic values (e.g. Cartwright, 2010), within the cartographic context art must be understood as hand craftsmanship as well. Within a multi-publishing framework, this means that the cartographer must have a clear vision of how the final maps in the service for all publishing channels should look and have the technical skills to realize the vision. Graphically and cartographically, the best results are achieved only by the interplay of a number of different types of software, of which the strengths and weaknesses are known and the best tools are always used for solving specific tasks. The challenge for cartography in a multi-publishing framework is that all of the resampling-based filtering approaches developed for images, audio and video data (Zedler and Ramadan, 1997) are unsuitable for maps. Since legibility and clarity of the maps must be preserved, symbol, colour and typographic design have to be tailored for all channels, scale-levels and use-contexts separately.

The map design process needs to find a balance between preserving the visual coherence throughout the whole map series while at the same time presenting context-aware information which characterizes the individual map types. Suitable methods for preserving the coherence appeared to include the use of consistent design in the map series as well as the use of several graphical layers throughout the whole set of maps for each scale level. It appears that the workload can be optimized by designing the graphical separation in maps for different use contexts as small as possible, and simultaneously making use of similar graphical layers as much as possible.

While this research raised challenges for designing context-aware maps for outdoor leisure activities using a multi-publishing service, future research is needed to improve the clarity, intuitiveness and simplicity of the maps aimed at specific user groups, such as the elderly and visually impaired people. Further investigation is also needed on the systematic characterisation of the publishing channels and their implications for map design in order to begin development work on the portrayal layer automating the map production workflow for the multi-publishing map service. Finally, the separation between static and dynamic map contents needs to be reassessed in order to find the optimal solution from the perspectives of cartography and cost efficiency.

BIOGRAPHICAL NOTES

Dr Juha Oksanen is a specialist research scientist in the Department of Geoinformatics and Cartography at the Finnish Geodetic Institute. In 2006, he received his PhD degree in Geography from the Helsinki University. His focus area of research is cartography, geovisualisation and uncertainty-aware geospatial analysis.

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