Solutions for LBS maps

Responsible persons:

Alistair Edwardes

(Overall)

Thomas Grossmann

(Revision)

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1. Solutions for LBS maps

Learning Objectives

- On completing this lesson you will be able to describe the different constraints inherent in a mobile device and how they impinge on the effectiveness of presenting cartographic information. With respect to these constraints you will be able to suggest different approaches to portraying information that can help to overcome these deficiencies.

Please have a look to the following illustration. Learn about the different constraints which are inherent in a mobile device by clicking on the elements memory chip, display, antenna. For returning to the starting state of the animation, click the clear button.

<div style="border: 1px solid red; background: #d3d3d3;">

Only pictures can be viewed in this version! For Flash, animations, movies etc. see online version. Only screenshots of animations will be displayed. [link]

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1.1. Portrayal of Geographic Information

Introduction

The lesson **Techniques for LBS Cartography** described various constraints that a mobile device has in comparison to more conventional technologies, such as a desktop computer. Amongst these restrictions were:

- Small display screens with low resolution
- Low bandwidth and intermittent network coverage
- Limited memory and computational power

In addition to theses physical limitations, Lesson **Designing maps for LBS** described more human factors that must also be considered. These included, that mobile device usage is:

- Based on short and frequent interaction sessions
- Related to specific activities which are tied to different types of services
- Related to context (e.g. location, time, etc.)

In those lessons such factors were dealt with from a relatively conventional cartographic perspective, in terms of how map content can be compiled to make it relevant, how interaction with maps can be enabled, how the design and styling of maps can be best performed to cope with constraints, and how different techniques for map provision can be used to optimise the usage of the available resources.

In this lesson we will consider such factors again, however, now we will take the perspective of developing the functionality of the map interface in ways that enchance the visualisation of information by fundamentally changing how the information is *portrayed*. This is done to cope with three different types of restriction:

- Physical constraints - limitations imposed by the device and network infrastructure
- Human factors - limitations on map reading caused by the nature of mobile use
- Graphical constraints - restrictions from the graphical styling used to depict information

1.1.1. What is Portrayal?

The International Organization for Standardization (ISO) defines **portrayal** as "presentation of information for humans" (ISO-19117 2002). The vagueness of this definition is representative of the abstractness of the concept in general. In the ISO standard the main concern is to define methods for styling geographic features. However it notes that, ``Portrayal shall not be limited to visual rendering, but may include audio, tactile and other media'' (p.9), In this sense, portrayal of geographic information can also be seen as being concerned with a number of other techniques for presenting information that exploit one or more properties of a map to enhance its abilities for communication in particular circumstances. These techniques include:

1. Changing the *level of detail* [1] used to show map features at different scales
2. Distorting the geometry of the map, for example using map projection or a variable scale
3. Presenting the the features of the map topologically by relaxing other geometric properties
4. Using different forms media to portray the information (e.g. visual, audio, and tactile)

In the next units each of how each of these aspects can be exploited to alleviate the constraints imposed by mobile device clients will be described and techniques to perform the portrayal operations dynamically explained.

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[1] Changing the complexity of a geographic representation dependent on map scale and size of display.

1.2. Selecting detail

Learning Objectives

You will be able to ...

- describe the physical constraints on mobile devices and how they effect the rate at which a map can be rendered
- describe the steps involved for progressive vector transmission
- describe the steps involved in grouping of points of interest, using cluster and expand techniques.

1.2.1. Level of detail

Databases of Geographic Information are able to store huge volumes of complex data about earth. The problem is that when we view the data, for example on a map, only a small part of it can actually be seen. There are two main reasons for this.

- The *scale* at which the data is shown
- The *resolution* of the device on which the information is displayed

Scale

We might think of the scale as relating to how far away the objects being shown are from the viewer. Clearly, the further you are from something the smaller it will appear and so the less detail about its shape you will be able to make out. In maps to ensure that features can still be displayed at small (i.e. distant) scales, they are symbolised so they always appear the same size, in effect enlarging them. This causes additional problems when large amounts of detail are shown because it makes the map appear cluttered and difficult to read. This was shown previously in the interaction in the Unit on **Maps on Small Displays**

Resolution

Resolution relates to the ability of the device presenting the data to draw detail. For a computer screen this depends on the number and size of pixels. For a paper map, on the smallest size of a dot of ink that can be printed. As you have seen in previous in the unit on **Display Facts**, for mobile devices the resolution of the screen is very low and in addition the size small. There is also a third factor that is important when data is shown on a screen which is how fast it can be rendered. On computers, this will depend on the speed of the processor or the graphics card, and if the data is being accessed over a network, how fast it can be downloaded. For mobile devices this is both these factors are limited, meaning that rendering large volumes of data takes a very long time.

LOD Techniques

Level of detail (LOD) techniques aim to address these problems by selecting only a small proportion of the data to show at particular scales. Because only a limited amount of the detail will be anyway visible this does not effect the graphical impression. To achieve this level of detail techniques need to consider three factors:
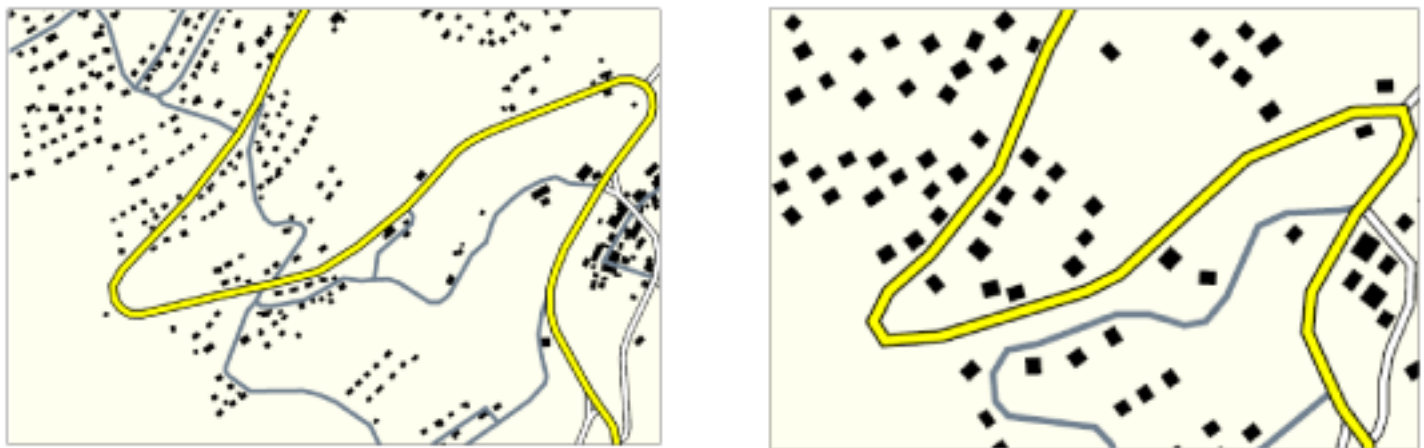
- How do we select only that portion of the data that has meaning in the context of the resolution of the viewing device?
- How do we organise the data so that different levels of detail can be managed effectively?
- How much data must be presented to convey the information content of the scene?

(Clark 1976)

Such techniques are used in most technologies for graphically displaying information, for the example of three dimensional models see the lesson **Advanced 3D modelling** . Here we focus on techniques for two dimensional maps.

Levels of detail for a river at different zoom levels. 100% (left-hand figure), 50 % (figure In the middle) and 37.5 % (right-hand figure)

Buildings and road network and their representation at the LoD 1:25'000 (left-hand figure) and 1:100'000 (right-hand figure)

The images above show examples of levels of detail from (Cecconi et al. 2002) for different types of geographic features.

1.2.2. Progressive Vector Transmission

Progressive vector transmission deals with the problem of viewing large volume vector datasets by progressively adding data to a model with less detail. On the one hand, this means data can be streamed to a client rather than downloaded in a single chunk. On the other, it means that the amount of detail shown can be limited to the scale at at which it is being shown and the resolution of the screen on which it is being displayed.

Steps

Progressive vector transmission has been studied by a number of different researchers for example, (Bertolotto et al. 2001), (Buttenfield 2002), (Brenner et al. 2004), and (Yang 2005). All these approaches share the same basic steps. We will draw on the approach of (Yang 2005) to illustrate these. This streams data for lines and polygons to a client.

The first step answers the question of how to select a meaningful portion of the data. The method used here employs the line simplification algorithm of (Visvalingam et al. 1993). This allows points of a line to be ranked in order of their importance to the shape.

The second step is how to organise the data. Since the points have been ranked they can be sent to the client in order of importance. To do this a set of instructions is generated that tells the client what to do with a point when it recieves it.

The third step is to decide how much data to show. This is not an easy question to answer. One method in cartography is to use the Radical law ((Toepfer et al. 1966), (Dutton 1999)), which states the total number of points that should be

$$n_f = n_a \sqrt{\left(\frac{M_a}{M_f}\right)^X}$$

shown at different scales. The equation is shown below.

In the equation: n_f is the number of objects that should be shown on the map at the final scale. n_a is the number of objects at the source scale. M_a and M_f are the denominators of the source and derived scales respectively. The exponent X is a parameter that can be varied according to the feature type. Toepfer and Pillewizer specified that a value of 1 should be used for point symbols, 2 for linear symbols (including points along digitized boundaries) and 3 for areal symbols (e.g. islands).

Example

Use the animation to explore a data set that has been organised for progressive transmission. You will need to select one of two modes. In the transmission mode the scale is constant, but you can vary the number of points displayed by moving the slider. In the zoom mode you can change the scale of the dataset which will cause the data to be zoomed and the amount of detail to be varied. You can also change the exponent value used in the Radical law.

Experiment with the choice of exponent in the Zoom view. What do you think is a good exponent for the Radical Law? How does your choice compare to the suggestions of Topfer and Pillewizer? If it is different, Why should it be different?

> Topfer and Pillewizer's suggest an exponent of 2 for lines such as these boundaries. However you have probably found that a higher exponent is more appropriate. This is because they worked with paper maps in their experiments which have a much higher resolution than your screen.

1.2.3. Cluster and Expand

One of the most commonly used types of data in LBS are points of interest. The user should be able to obtain points of interest that are relevant to them within the map view. The problem here is that it is difficult to know how many POIs will be found and where they will positioned. This can lead to a very cluttered map that is difficult to interact with. You will have thought about this problem previously in the **maps on small displays** interaction of the LBS Techniques lesson. Here, the solution to this problem will be to represent clusters of points of interest with a single symbol. Interacting with this symbol will cause it to expand and show the POIs that it represents. Hence there are two processes, clustering and expanding.

Clustering

There are many ways to cluster data sets of points. Here we describe the k-means technique. The idea is to position k points as the centers (means) of k clusters identified amoungst the set of points. k essentially defines the *level of detail* that is desired. The radical law can again be used to identify a suitable value. Here, we will fix a maximum value of k which is varied according to a minimum number of points required to form a cluster. The clustering algorithm works by performing two main steps over and over again until it has found a solution usually around four or five iterations are required to achieve this. The steps are:

1. Allocate - initially the centers of the clusters are defined randomly within the map space. For each POI the closest center is then identified and the POI is allocated to this.
2. Locate - for each center the mean of the points allocated to it is computed, e.g. sum of x coordinates/number of points, sum of y coordinates/number of points. The center is then moved to this position.

In the implementation here, after the solution has been found the number of points allocated to each centroid is counted. If there are fewer than a set amount (e.g. two) then the points are reallocated to their next closest center, but the center is not moved. This prevents the position of the center from being over influenced by the outlying points. You can experiment with the animation to see how the the algorithm works.

Expand

There are several ways to expand the clusters in response to the user's interaction. The technique here is to open up the clusters like a flower. The main idea in any approach is to present the POIs allocated to a center in such a way that the user can query them directly with their stylus. You can explore the basic principles of the cluster and expand approach using the animation below. Moving the slider bottom will show increase the number of points being shown. The "show clusters" option enters the cluster and expand mode.

Think about some other ways to represent clusters that can be expanded with user interaction. Sketch some examples on a piece of paper. What are the important considerations that you make in your designs

1.3. Varying scale

Learning Objectives

You will be able to ...

- describe the different device constraints that can be reduced by varying the geometric properties of the map.
- state the main components of the variable-scale transformation.
- describe how the map space can be represented as a rubber-sheet and the reasons why this can be useful.
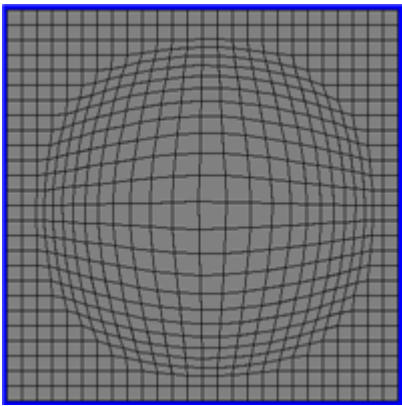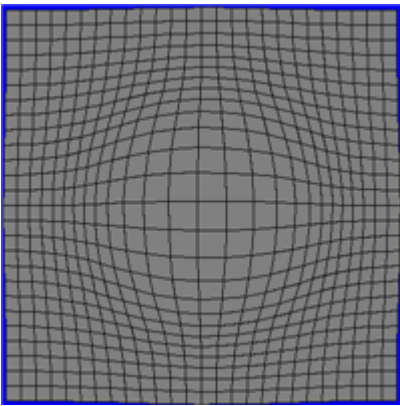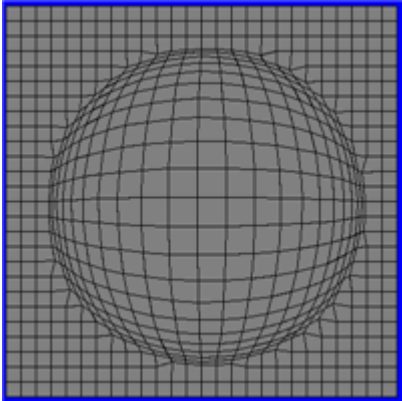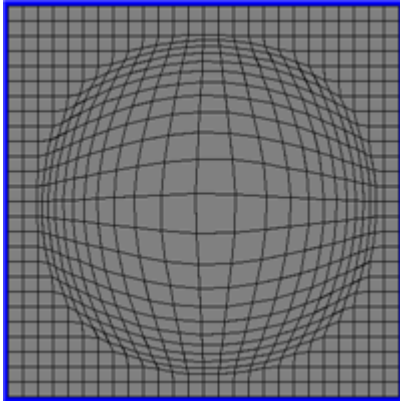
1.3.1. Detail in context views

Purpose

Level-of-detail techniques vary the amount of detail shown across the whole map according to a single scale. The idea of detail-in-context views is to instead vary the scale across the map to show more detail in some places than in others. Effectively this means that parts of the map will appear to be zoomed in (the detail) and other parts zoomed out or at their original scale (the context). Between there will be a smooth transition. The advantage of the technique is that you can at once focus on a specific area, in LBS this will be your current location, while still being able to orientate yourself within a much bigger space.

Detail-in-context views can be thought of as types of map projections that transform coordinates of features on the map according their distance from the point of focus. The transformation itself is therefore a simple function of distance. The function can take many forms, four different functions are shown using a square grid to illustrate how the amount of magnification changes.

Functions for detail in context views

| Linear (Carpendale 1999) | Gaussian (Carpendale 1999) |

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Hyperbolic Tangent (tanh) (Keahey et al. 1996)	Fisheye (Sarkar et al. 1992)

In what way do the different functions differ

> The functions all magnify by the same amount at the point of focus. The differences are in how the scale is allowed to return to the base scale of the map. Overall the amount of map space needs to stay the same so magnifying in one area means de-magnifying somewhere else. How this relationships is balance is the main difference amongst the functions.

Steps

Computing a detail in context transformation is in fact very simple. There are four steps:

1. Define a point of focus, e.g. the user's location, and a radius from this point over which the transform should be applied. Outside of this the scale should be the base scale of the map. This radius being used is quite obvious in three of the examples shown.

2. Convert the coordinates of all your geographic features into *polar coordinates* [2], with the *origin* [3] centered at the point of focus. To achieve this means you will have to measure the angle and distance of each point of the objects being shown on the map from the focus. In the examples shown above these points are the *interstices* [4] of the grid.

3. Apply the transformation to each point using a specified magnification value. Only some of the coordinates will need to be transformed. To work out which ones you will need to check how far the point is from the focus. This is the distance component of the polar coordinate. Those which are farther than the radius of the transform, or exactly zero, can be left alone. Those which are less than the radius need to be transformed. Most transformation functions require the coordinates to be *normalised* [5] over the radius. This means they take a value of zero at the focus and one at the radius length. Therefore, to normalise the distance simply divide it by the length of the radius. The function is then applied using the value of this distance. For example for hyperbolic tangent method this is simply tanh of the product of the magnification and the normalised distance, i.e. tanh(distance*magnification). Having applied the function you'll need convert back to the unnormalised distance by multiplying by the radius length.

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[2] A mathematical system in which each point can be determined by an angle and a distance.

[3] The point in which every coordinate is of value 0. The origin is used in cartesian coordinate systems.

[4] Space between objects. Different interstices result when a context transformation is performed. The further from the origin (in a polar coordinate system), the closer the objects are located to each other.

[5] In case of context transformation a normalization is done by simply dividing the distance of an object to the origin by the length of the chosen radius.

4.   Convert your *polar coordinates* back to *cartesian* [6]ones and draw the map objects.

1.3.2. Computing transformations

Computing variable scale transforms

The detail-in-context transformation works on the distance a point is from the focus, so you can look at how the function appears by plotting along a single dimension x. In this activity you will compute one of the transforms along a line, for example from 0..40. You can perform the calculations using a pen, paper and calculator, though you will find it easier to use a spreadsheet package like Microsoft Excel.

Functions

You should use one of the functions shown in the examples previously. The equations for these are:

Variable Scale Equations

Linear	$dist' \cdot \left(\dfrac{mag}{mag - (1 - dist')} \right)$
Fisheye	$\left(\dfrac{(mag + 1) \cdot dist'}{(mag \cdot dist') + 1} \right)$
Gaussian	$dist' \cdot \left(\dfrac{mag}{mag - \exp^{-\frac{dist'^2}{SD}}} \right)$
Tanh	$\tanh(dist' \cdot mag)$

Where **dist'** is the normalised distance from a point to the focus point and **mag** is the value of the amount of magnification at the focus. SD in the eqnation of the Gaussian is the standard deviation of the Gaussian kernel you can set this to 0.1 or try varying it.

Calculation Steps

In computing the values you will need to perform the follow the steps, you can put each in its own column of the spread sheet:

1.   Create a column of values for the x coordinates, i.e. 0 to 40
2.   Define a variables for the magnification, e.g. 2, the radius over which the transform should apply, e.g. 10, and the point of focus. The focus should be a point from your x value, e.g. 20.
3.   Calculate the distance from each point to the focus.
4.   Normalise the distance over the radius
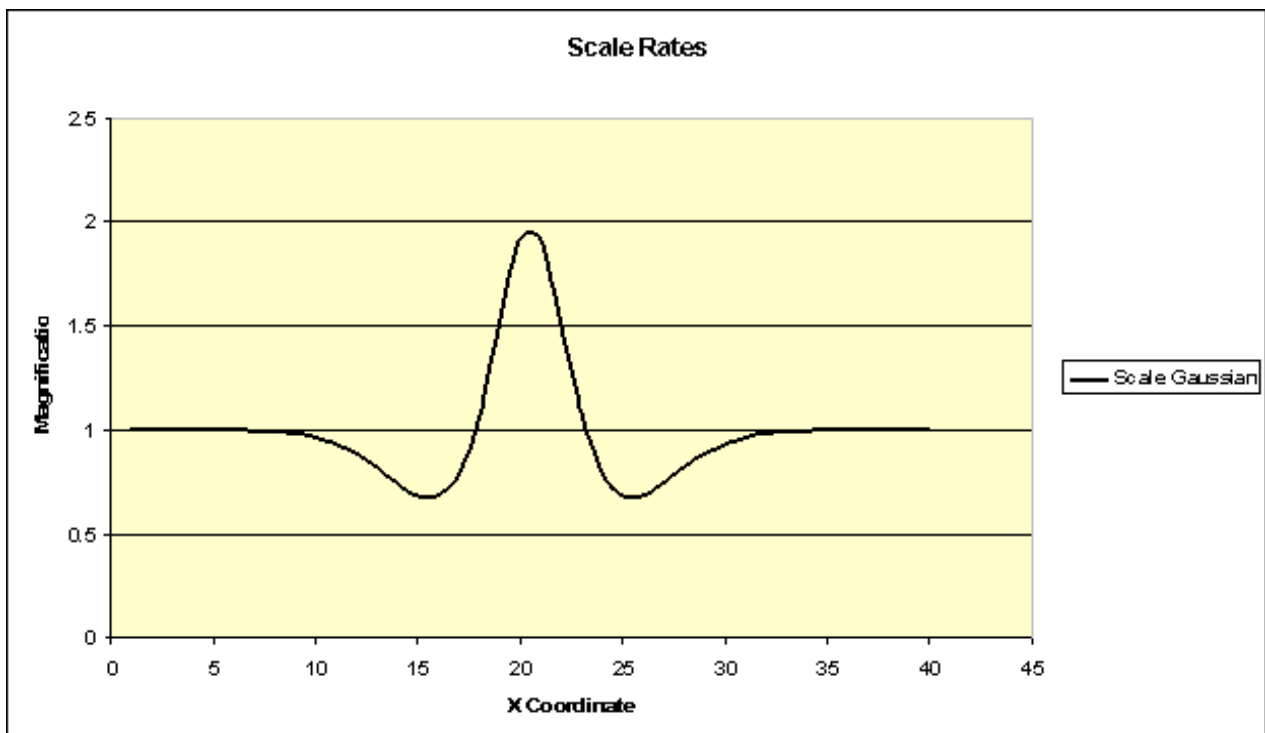
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[6] A mathematical system in which each point can be determined by a set of coordinates (depending on the number of dimensions).

5.   Compute the transformation on the normalised distance and un-normalise the result, i.e multiply by the radius. Remember the function only needs to applied to points that are within the radius and not zero.

6.   Compute the new x coordinate from the distances.

Graphing the function

It is useful to visualise how much the function is magnifying the map space at different points within the radius. To compute the scale create a new column and in this divide the difference between two steps of the transformed space with the equivelent in the untransformed space. For you first row you will have no entry. Plot these values in a graph against the untransformed x coordinates. Your graph should look something like the image below of the Gaussian function.Try changing the values for the magnification and radius and observe how it effects the graph. In particular, consider how the function demagnifies in some points and magnifies in others.

What is the relationship between the value of the magnification and the transformation function? Think about how you calculated the magnification in the graph.

Within the radius the magnification value (scale) is the derivative of the transformation function at a point. If you feel so inclined you can compute the derivative explicitly and try graphing this also.

1.3.3. Transforms in Action

Variable Scale Map Example

In this animation below you will be able to experiment with a variable scale transformation applied to a map. In this example we have used the function of (Harrie et al. 2002). This defines two radii. Within the first the map is at a constant magnified scale. Outside of the second the map is at a constant base scale. The transformation then varies the scale smoothly between. Having two radius has the advantage that in the focus region there is no distortion of the map because of the scale, which makes it easier to read.

Instructions for use

- Once the map has loaded, the first thing you will need to do is to click within the map and drag the mouse to define the focus region. You will see the two circles, the inner circle in red shows the region of map that will be magnified. The outer circle in green shows the limit of the transformation, beyond this the map will return to its base scale.
- On the right you will see an interactive graph of the magnification function. Moving the lower horizontal scroll bar will change the size of the green circle. Moving the vertical scroll bar will change the amount of magnification within the inner, red circle.
- To reposition the focus region simply click and drag again within the map.

1.4. Schematisation

Learning Objectives

You will be able to ...

- state the aspects that schematic maps abtract and how these are useful to LBS map users
- state the steps involved in generating schematic route maps.

1.4.1. Map Aspects

(Berendt et al. 1998) describe a typology of map types in terms of the *aspects* that they represent pictorially. Such aspects include everything that is depicted on a map, for example the geographic entities that are drawn and labelled, and the spatial relationships that amongst these. Their typology includes:

- Topographic maps - these aim to show the primary geographic characteristics of a landscape as precisely as possible (e.g. shapes of land, water areas, elevations, etc.)
- Thematic maps - these draw on topographic maps but describe qualitative information attached to a topographic basis (e.g. demographic information)
- General purpose city maps - These relax some of the constraints for precision in order to better emphasise labels and symbols for orientation in an urban environment.
- Schematic maps - these omit most of the topographic information to describe sequences and conjunctions of networks
- Sketch maps - these provide highly specialise *ad hoc* purposes omiting all but a few characteristics of the environment to depict the essential situational information relating to specific places.

Human factors

The important thing to recognise about this typology is that the aspects shown by a map relate to how the map is used, and so to human factors. Topographic maps need to be generic, so they make as few assumptions as possible about the map's use. City maps support orientation of people in a city. Here, the factors that are important are *landmarks* [7] and street names since these are what the map user will look out for in trying to find their way around. When people travel on networks their movement is highly constrained. The way that they encounter space is by travelling along paths and changing between these at nodes. Hence, they do not need to know much about the space outside of the network. In providing maps to people navigating such networks much of the geometric information about the network can be relaxed. Only the topology of the network needs to be absolutely preserved. In each case, the point of abstract specific aspects is to reduce the amount of effort required to consult and follow the map, making the map use more efficient within the particular situation.

In this unit we will concern ourselves with schematic maps for transport and navigation and the types of aspects that these select. To give an example (Berendt et al. 1998) look at maps of transport networks. They list the aspects of the geographic entities these choose to represent, for example:

- Exact locations - the positions of stations within a city should be preserved as far as possible.
- *Orientation between stations* - the approximate orientation between stations in terms of cardinal directions should be maintained.
- Distance between stations - rough, as the crow flies distances between stations should be representative.
- *Locations of start and end points* - The ends of lines should coincide with with terminal stations

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[7] Includes basically anything that is easily recognizable, such as monuments, buildings etc.. In geographic information science landmarks are assumed as being important concepts of navigation through space.

The London Tube map is perhaps the most famous schematic map. It describes the underground transport system in london in a schematic form. Look at the map (click on the image below to obtain a large version). Write a list of the different aspects that are shown. Why are these aspects important to the way people think about space when using the transport system that is under the ground?

Can you think of some situations for mobile use where schematic maps might be useful? What difficulties can you percieve in their use in these situations?

> The most obvious use of schematic maps is in navigation where the user is largely constrained to a network. This is particularly the case for car drivers. Schematic maps are also useful for pedestrians and public transport users, however they can suffer in these situations the navigable space is much less constrained to a network. For example, often using public transport you must change between a bus or tram. If this is not at the exact same station the user needs to know how to get to the next on, communicating this information is quite difficult to do using a single schematic map. Schematic maps can also be used to show other types of network. A network of friends or workers at different locations might be an example of this. The problem here is in deciding what the nodes and links of the network should mean, for example the nodes could be locations or people, and the links distance or ties between people.

1.4.2. Making Schematic Maps

Creating schematic maps computationally requires complex algorithms to achieve correctly. Several researchers have suggested methods, for example (Elroi 1991), (Avelar et al. 2000), and (Cabello et al. 2002). You can experiment with the method of Cabello **online**. In the animation below you can follow the main steps that Elroi suggests for performing schematisation.

> **Only pictures can be viewed in this version! For Flash, animations, movies etc. see online version. Only screenshots of animations will be displayed. [link]**
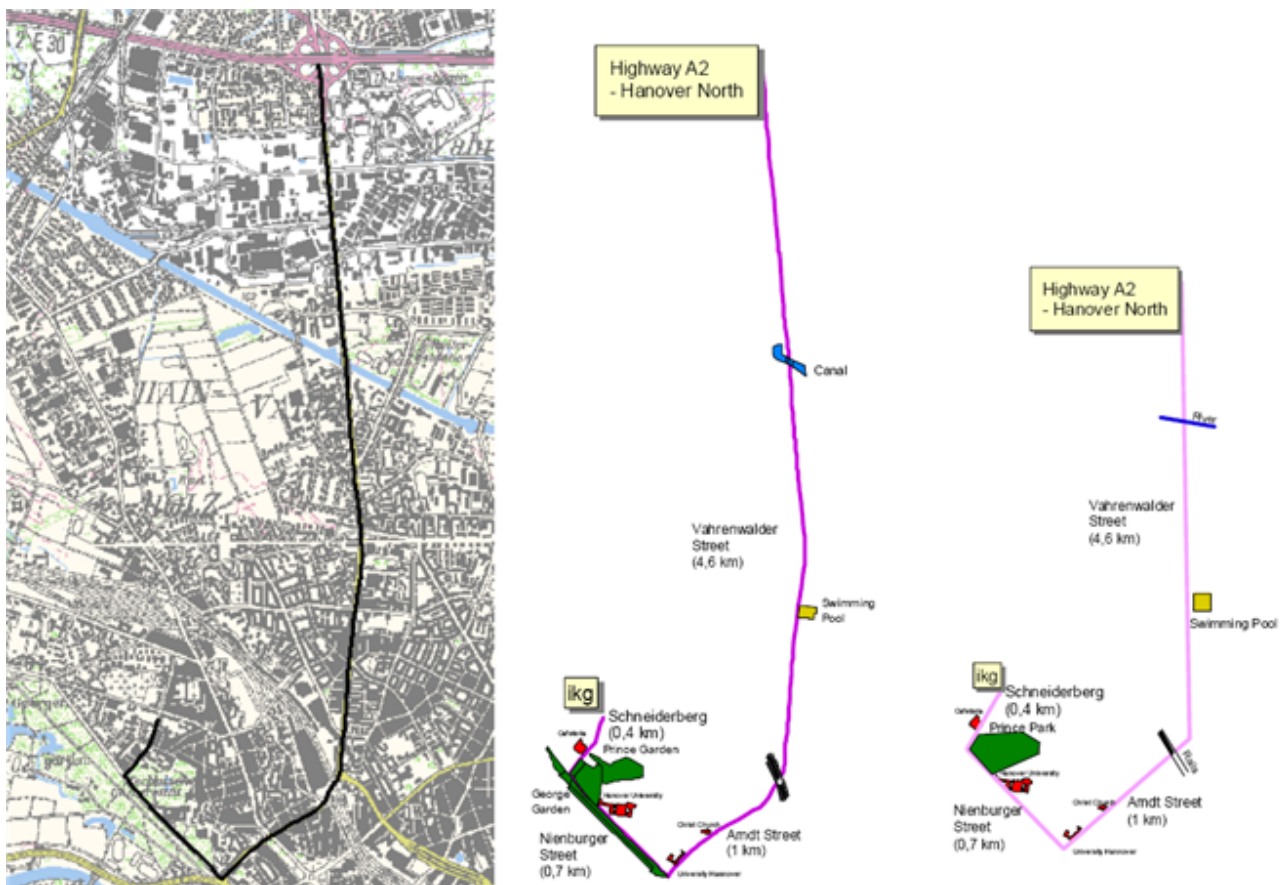
1.4.3. Route maps

Route maps abstract aspects of road networks that relate to the way people encounter space while driving. There are two particular types of feature here, the paths of the network that are transited and the places where the driver needs to make decisions, such as turning. Unlike for the underground map, it is much harder when driving to identify a these features and make the correct decisions at turning points. Hence route maps need to include a set of aspects that make this clear to the driver.

Landmarks

One important feature that needs to be shown on route maps is landmarks. Along a path this tell the driver that they are on the right route and how far along the path they are and so how soon they will need to make a turning decision. At decision points they mark the point itself, e.g. "*At the post office* turn left.", and disambiguate between different possible choices of paths, making the turning instruction easier to understand, e.g. "Turn left *under the bridge*.".
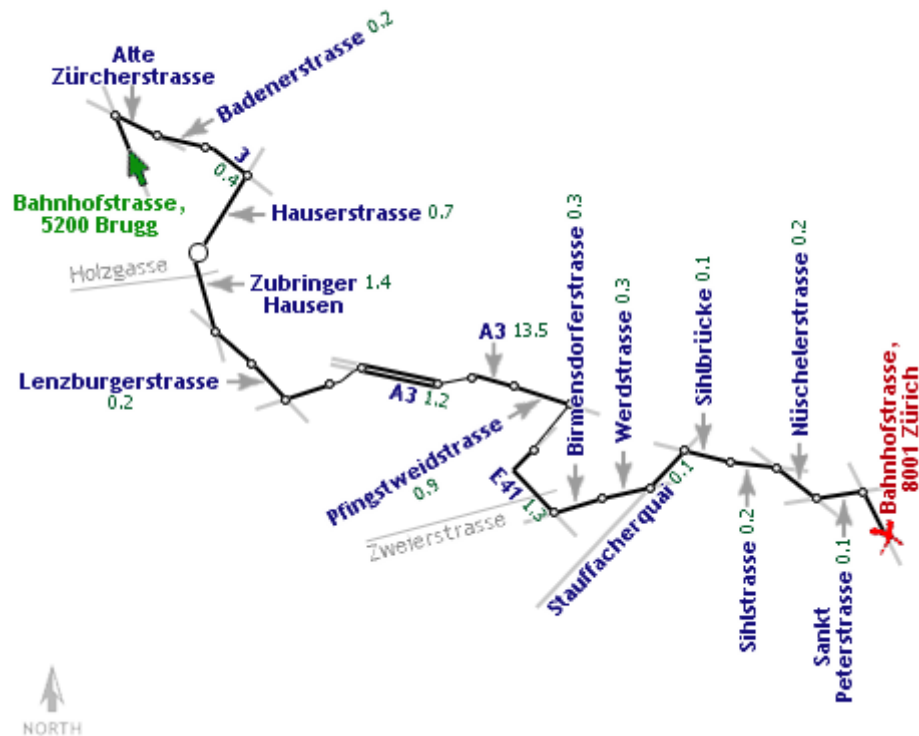
Landmark corridors

(Elias 2002) has looked at how landmark information can be extracted from digital landscape models and presented as route corridors for drivers. The graphic below illustrates the processes she uses to generate the maps.

1. Compute a route between the desired start and destination points of the map user.
2. Identify landmarks within a buffer of this route (e.g. 20 metres).
3. Simplify the shapes of the landmarks and the route for the final presenation. As you can see in the final map the generalisation of the shapes of landmark buildings is strongly dependent on the uniqueness of their outline. Buildings with characteristic shapes are retained so as to better communicate the visual aspects of the building to the driver.

LineDrive

(Agrawala et al. 2001) has produced a system called LineDrive that describes routes even more abstractly, as a sequences of lines. The image below shows and example of the output of LineDrive.

You can play with LineDrive yourself of the the **MSN map site**. Press the "Get Directions" button to define a route and be sure to check the "LineDrive" option for the map style. What types of aspects do these maps present?

1.5. Changing Media

Learning Objectives

You will be able to ...

- state the main steps used in creating route instructions from a database of geographic information.
- describe how the syntax of route instructions can be modelled.
- suggests different considerations required to decompose sets of geographic features into instructions.

1.5.1. Making Maps Talk

Introduction

The final method of *portrayal* [8] that we will consider will be how geographic information can be presented users of location-based services in the form of text or audio. There are a number of reasons for doing this. There are many situations where the user does not want to be distracted by looking at a map, this is most evident in navigation, where the user wants to focus on the task at hand, e.g. driving, with the minimum of interuption. (Streeter et al. 1985) for example has shown in such situations that navigation is more effective if verbal instructions are given than if a standard map is provided. Other examples might be in following a guided historical tour when the user wants to look at the interesting features of the landscape rather being distracted by a mobile device. (Bartie et al. 2006) describes such a system that provides audio descriptions of historic buildings in Edinburgh that can be seen by the user as they walk around the city.

Changing the medium of the map in such a way is a challenging problem because it requires the model of information to be shifted from one that is spatial, e.g. symbols on a two-dimensional planar map, into one that is based on narrative. As such natural language based representations tell a story which involves a sequences of events. We will look at how this story can be automatically developed for the example of in-car or pedestrian navigation. This starts with a geometric description of a route and ends up with a set of spoken instructions describing how the route is navigated.

We can think of the process of generating a route description as consisting of a translation between two models. On the one hand, there is a spatial model that represents information about geographic features geometrically. On the other, there is a language model that represents geographic features in terms of the roles they play within a natural language sentence.

Steps of route description

The animation below illustrates the steps required to compute a route description.

1.5.2. Chunking a Route

In this activity you will think about the problem of chunking in more detail. To do this you will need to printout a copy of **this pdf file** showing a map (loosely based) on Zurich. You will use this map to draw on decision points where a turn type instruction must be given.

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[8] A presentation of information for humans, including visual rendering, audio, tactile and other media. (please refer to chapter "Solutions for LBS maps")

When the route description is first computed by the spatial model, every road link and junction node will be included. If this is used as it is the instructions can become very tiresome. For example every time the driver passes by a side street and instruction such as "Continue straight ahead" would be given. The aim of chunking is to limit the decision point instructions to only those those places where the driver must stop and make a turn. There are three main situations where this is important.

1. White lines - this is to avoid the type of situation described above. An instruction only needs to be given when the driver will come to a stop and make a turn. You can think of these points as where there is a white line painted across the road indicating the driver must stop. Usually these points are determined by the relative priority of the road but this information is often not available explicitly in a database, so instead you need to think of rules that account for this situation. For example when the class or the name of the road changes.
2. Concatenated instructions - Sometimes multiple turns will occur very quickly one after the other. In these situations the driver cannot hear the whole of one instruction before the next one must be given. To solve this problem instructions must be concatnated. For example "Turn left ... *then immediately* turn right ...".
3. Slip roads - slip roads are very short segments of connecting roads that transit from one road to another. For example these occur when two lanes are split at a T-junction or when leaving a Motorway (Autobahn). In most cases instructions on how to navigate these roads can be omitted entirely and only the turning relationship between the two main roads considered.

On the map you have printed out mark the points where instructions need to be given and concatenated. Write down the rules you used to decide on why the locations were decision points.

Click for pdf map

1.5.3. Instructions Syntax

In order to produce the instruction we need to define a syntax of how the instuction set should look. This is essentially a cannonical model that describes how words are put together using information from the route description. We will define the syntax using a version of the Backus-Naur-Form (BNF). This is a simple notation of encoding how sentences are structured.

Backus-Naur-Form - Elements

The main element in BNF is the symbol. Symbols are defined using the syntax <SYMBOL_NAME>, where SYMBOL_NAME is the name of a symbol you wish to describe. For example <Start_Instruction>.

A symbol can be defined using other symbols. Here, the definition is made using the notation ::= . Hence, an expression in BNF can be thought of as an equation that relates one symbol to a set of others.

We will use two other types of element in the definitions. Strings are literal phrases that should be included. They will be marked up using double quotes, e.g. "Start on". Objects will relate to the geographic features encoded in the route description. There will be three types of object - *landmark*, road and junction. They will be marked simply with the word describing the type of object. To indicate a property of an object we will use a . for example road.name indicates the name of a road.

Thus we might define a road link instruction as:

<Road_Link_Instruction> ::= "Continue along" road.name "for" road.length "passing" landmark.name

which might then produce a text instruction such as:

"Continue along Werdmuehlestrasse for 200 metres passing Spielzeug Museum".

Backus-Naur-Form - Operators

There are a number of useful operators that we will also need to use. The most important is the "or" sign | . This means that the instruction should use one of a number of options. () Brackets can be used to indicate a list of options.

For example we could define a symbol:

<Turn_Indicator> ::= "turn" ("left" | "right") "onto" road.name

which might be used to produce:

"turn left onto Werdmuehlestrasse".

Another operator is known as the Kleene star. The notation is ( )* This indicates that a symbol or set of symbols should be repeated. For example:

<Road_Link_Instruction> ::= "Continue along" road.name "for" road.length "passing" (landmark.name "on your" ("left"|"right"))*

might be used to produce an instruction such as:

"Continue along Werdmuehlestrasse for 200 metres passing Spielzeug Museum on your left, Museum Strauhof on your right".

Finally, we will use the optional operator which is indicated using square brackets [ ]. This means that the definition in the brackets is optional for the sentence. For example we might place the the landmark part of the previous symbol in brackets since there may be no landmarks found along a particular stretch of road, i.e.:

<Road_Link_Instruction> ::= "Continue along" road.name "for" road.length ["passing" (landmark.name "on your" ("left"|"right"))*]

BNF Summary

Notation	Meaning
< >	A symbol element
" "	A string element

object	a road, junction or landmark object
object.property	dot operator indicating an object property
::=	Defines a symbol (is a)
( )	Seperates a set of elements
|	or
( )*	Repetition
[ ]	Optional

Generating Route Instructions

In this activity you will define the syntax of a set of route instructions using BNF and then apply these to the map that you chunked previously. This will allow you to write out a sequence of instructions using the features that are shown and named along the route depicted on the map. You can either use the start and end of the route shown or define your own somewhere along the route.

1) Formulate Instruction Syntax

You should start your syntax from the following definition:

<Instruction_List>::=<Start_Instruction>

(<Junction_Node_Instruction>|<Road_Link_Instruction>)* <Destination_Instruction>

which is to say a list of instructions consists of a starting instruction followed by any number of junction or road instructions and finally a destination instruction.

Expand out each of the symbols to give them their own defintions. You will probably find it useful to introduce some symbols of your own when doing this, e.g. <Turn_Instruction>

2) Generate Natural Language Instructions

Generate instructions for the route you previously chunked shown in the map. Your set of final instructions should read something like:

"Set off from Bahnhofquai with Hauptbahnhof to your right"

...

"Continue 1.5 kilometers along Waisenhausstrasse and Werdmuehlestrasse passing Speilzeug museum on your right"

...

"At the Augustinerkircher turn right onto Oetenbachgasse"

...

"Arrive at the Zuerichsee Pier"

3) Listen to Your Instructions

You can try listening to your instructions using an online *Text-to-Speech* [9]engine. For example **AT&T's Natural Voices**, **FestVox**, **German Festival** or **Cepstral**.

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[9] A computer engine which synthesizes text into speech.

What problems do you find with the conversion to speech?

The most likely problem you will encounter is the pronounciation of place and road names. Another problem may have been the duration of pauses between words. Typically TTS engines provide methods to better control how sentence is spoken for example by spelling out phrases phonetically or inserting pauses. Data providers often also provide phonetic gazatteers that give both the written names of places and the way they are pronounced. You can try to improve how your sentences are spoken by changing the spellings of words so they are closer to the way in which they are spoken.

1.6. Summary

In this lesson you learned about techniques to dynamically portray geographic information for LBS maps. These considered different physical and human constraints that come from mobile devices and the types of environments these are employed in. In particular, you explored five main techniques for *portrayal* in LBS.

- Progressive vector transmission coped with the issue of low network connectivity and restrictions on the device such as the processor speed and the size and resolution of the screen. This limited the amount of information that need to be displayed at any particular time.
- The cluster and expand method dealt with the issue showing large volumes of points of interest which can overlap and be hard to read or interact with. The method reduced the *level of detail* by defining clusters and showing these using central points that could be expanded on interaction.
- Variable scale projections tackled the problem of small screens by changing the scale of the map around a central focus of interest (postioned on the user's location).
- Schematic maps can abstract information accord to factors involved in the map use. In particular you looked at maps for describing routes and the important factors that these need to show.
- Finally, you considered how route maps can be translated into spoken instructions and the steps needed to perform this operation.

1.7. Glossary

Backus-Naur-Form:

Metasyntax used to describe formal languages. The Backus-Naur-Form defines the syntax of a programming language by using two sets of rules, lexical rules and syntactic rules.

cartesian coordinate system:

A mathematical system in which each point can be determined by a set of coordinates (depending on the number of dimensions).

clustering:

Process of grouping Points of Interest based on spatial closeness. Different techniques of clustering exist, like the k-means technique, which includes two main steps, allocate and locate.

interstices:

Space between objects. Different interstices result when a context transformation is performed. The further from the origin (in a polar coordinate system), the closer the objects are located to each other.

landmark:

Includes basically anything that is easily recognizable, such as monuments, buildings etc.. In geographic information science landmarks are assumed as being important concepts of navigation through space.

level of detail (LOD):

Changing the complexity of a geographic representation dependent on map scale and size of display.

normalization:

In case of context transformation a normalization is done by simply dividing the distance of an object to the origin by the length of the chosen radius.

origin:

The point in which every coordinate is of value 0. The origin is used in cartesian coordinate systems.

polar coordinate system:

A mathematical system in which each point can be determined by an angle and a distance.

portrayal:

A presentation of information for humans, including visual rendering, audio, tactile and other media. (please refer to chapter "Solutions for LBS maps")

portrayal of geographic information:

Techniques for presenting information that exploit one or more properties of a map to enhance its abilities for communication in particular circumstances.

Progressive Vector Transmission:

Technique that deals with the problem of viewing large volume vector datasets by progressively adding data to a model with less detail.

schematic map:

Schematic maps are simplified representations of geographic space. They accentuate specific aspects of information by omitting less useful aspects. E.g. a tube map lacks of true locations of tube stations and their distances to each other to make the most important information more salient: Which tube(s) do I need to come from where I am to where I want to go?

Text-to-Speech:

A computer engine which synthesizes text into speech.

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