Adding Value for the Navigation User

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1 Introduction

You've lost your way in a new town and you stop to ask a local how you get to Park Street. How would they describe it? Probably something like this: "Go to the next roundabout and turn left, then keep going until you see the BP™ Petrol Station, turn right straight after that and you'll go past the Kings Head pub, I'm pretty sure Park Street is after that on the left – I think there's a post office on the corner, you can't miss it". Ask a current navigation system the same question and you'll probably get a series of very accurate distance-based instructions, e.g. "Left turn in 300 metres" but you might not have the confidence that you had when you saw the petrol station and the pub that had been mentioned, even though your helper was bit unsure.

It sounds common sense, but wouldn't the ideal system use the best of both: the accuracy of a well engineered GPS navigation system and the local landmarks that people regularly use to give directions? This common sense view is supported by compelling research arguments that the inclusion of landmarks would aid the task of navigating in an unfamiliar area with a navigation system:

- Basic human navigation strategies employ landmarks: they form key elements within cognitive maps of the environment, aid the learning of the environment (Evans et al 1984; Golledge 1993), and are used in way-finding strategies (Alm 1990).
- Landmarks are valued as information items by drivers: they were rated the second most popular information type (after left-right directions) requested by a driver from a passenger for aiding navigation (Burns 1997). This finding is confirmed by other studies (Streeter & Vitello 1986; Wochinger & Boehm-Davis 1997; Burnett 1998).
- The usability of navigation systems (defined as a function of effectiveness, efficiency and satisfaction, ISO 9241 - part 11, 1998) can be enhanced by including landmarks: they can improve the proportion of correct navigation decisions (Bengler et al. 1994). They can (in comparison to a display that emphasises distance rather than landmarks to locate a manoeuvre) reduce the mean number of glances to a display and result in lower perceived workload (Burnett 1998), and can increase confidence of the location of turnings and satisfaction with the information presentation (Alm et al 1992). Strong preferences have been shown in simulator trials for vehicle navigation interfaces that included landmarks (Green et al 1993), and this impacted on driver preference to an even greater extent than the modality (auditory vs. visual) of the HMI.

Therefore, the inclusion of landmarks within navigation instructions has the potential to: (1) enable navigation systems to more effectively aid navigation decisions; (2) reduce the cognitive effort and distraction imposed by these systems; and (3) result in systems which are more accepted by the driver. See (Burnett 2000) for a comprehensive review.

So, this is all very well, but incorporating landmarks within navigation systems is no small task. New data has to be available, accessible, accurate and easily maintained. If data can be used for multiple purposes then the business case is stronger for the database developers. This can be achieved by extending the use of existing data e.g. using current POI's (Points of Interest) as objects to navigate *by* as well as places to go *to*, or by only adding landmarks that can also be used for other systems and users. Also, if new 'objects' can be identified as appropriate without the need for field visits then the cost-benefit is reduced. All this points to the need for research findings to be translated into practical design advice for database developers and system manufacturers; i.e. a method by which to choose which objects are the most valuable as navigable landmarks. This was the main aim of the REGIONAL project and the main findings of the project are reported here.

2 Learning from oft-used landmarks

Most previous studies that have been conducted to identify appropriate navigational landmarks have simply listed those most frequently used (invariably traffic lights, traffic signs, shops, petrol stations and bridges). However, these results are of limited use as they are influenced by the conditions of the study from which they result and are only truly valid for that particular set of circumstances (road environment, availability of landmarks, driver characteristics). The REGIONAL project conducted two detailed direction-giving studies; not to provide a simple list of the landmarks that should be incorporated in systems, but to begin to identify the attributes that caused them to be chosen over other objects

The studies were conducted in the 2 urban environments of a town (population 60,000) and a city (population 295,000) with 32 and 36 participants respectively. Participants were required to provide directions from the start to the end of each route as they would to someone who was unfamiliar with the area. In both studies a dual methodology was used: half of the participants did not know the area and gave directions based on viewing a video tape of the route (Video condition); the other half knew the areas well and gave directions from memory, prompted by a line drawing outline of the route (Cognitive Map condition). The reason for the dual methodology was to enable identification of the optimum landmarks based on both visual characteristics and ease of remembering. As an indication of the variety of landmarks mentioned, those that were most frequently selected in the City study are shown in Figure 1.

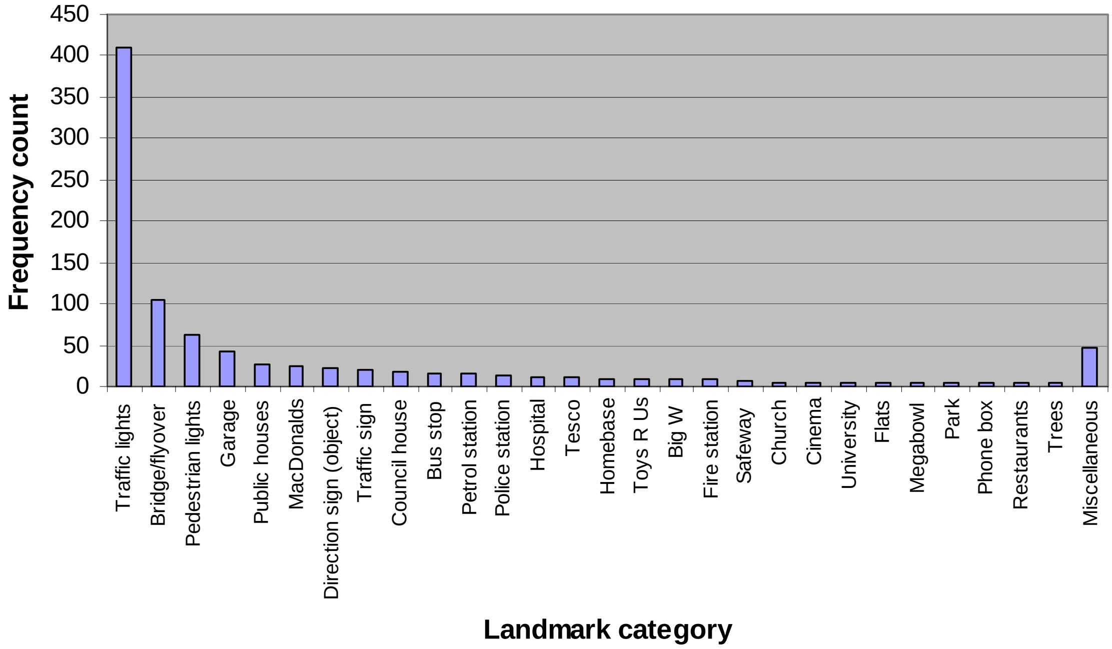

Figure 1. Landmarks used in City direction-giving study

To generate the attributes that characterised good landmarks, the research used experts to compare the attributes of the landmarks used/not used, both across categories (e.g. petrol stations vs. public houses) and as individual objects within a category (e.g. petrol station 1 vs. petrol station 2). In addition, several other sources of information were used to supplement this analysis, namely: consideration of theoretical information processing models; review of relevant applied research literature; informal content analysis of video tapes of the routes used in the direction-giving study and analysis of participant post-trial protocols.

3 Guidelines for selecting ‘good’ landmarks

From the direction-giving study and from the additional sources of information mentioned above, several attributes were identified as influential when selecting ‘good’ landmarks. These are summarised below. The more attributes the landmark possesses, the more valuable it is likely to be.

Easy to see, i.e. the object itself and/or the sign associated with it is:

- Brightly coloured or lit
- Attention grabbing (e.g. moving, flashing lights or animated)
- Large
- Have a unique shape, profile or colour (the object can be identified without seeing the detail)

Easy to spot/find, i.e. the object is:

- close to the roadside
- not set back in relation to other buildings
- in a typical location for that object

- central to the driver's vertical (up or down) line of site (taking into account where they would be looking whilst approaching /undertaking a manoeuvre)
- central is to the driver's horizontal (left or right) line of site (taking into account where they would be looking whilst approaching /undertaking a manoeuvre)
- visible from a distance

Has pre-warning of its existence, i.e. there is

- explicit preview information (e.g. for traffic lights, there may be a warning sign indicating traffic lights ahead, for a museum, a tourist sign may indicate its location)
- implicit information is there to suggest that the object might be coming up (e.g. entering a village may suggest a pub or church will be present; the flow of a river may indicate where a bridge is likely to be)

Easy to pick out from its surroundings, i.e. there is:

- Little/no visual clutter next to or behind the object
- Little/no visual clutter in front of the object

Is an object that a driver interacts with as part of driving, i.e. the object (and/or sign):

- Is used for planning (strategic) aspects of a journey (e.g. a driver may use objects such as signs, car parks and petrol stations to help them decide on routes, where they might stop on-route, where to park etc)
- Impacts on the physical driving (control) task (e.g. a driver will physically react to objects such as traffic lights, lane markings, give way signs, bends etc)

Ideally located for the task, i.e. the object is:

- Close, laterally, to the point where the driver would start to make a turn
- Close, longitudinally, to the manoeuvre (note: usefulness of an object decreases rapidly with distance after a manoeuvre, and decreases at a lesser rate with distance before a manoeuvre
- Spread over a large distance (ideal for 'progress') or precisely located (ideal for manoeuvres)

Other criteria that may also contribute to landmark value (but have not been shown empirically to do so) are the following:

Familiar to drivers, i.e. the object (and/or sign) is:

- Stereotypical and easily identified (by drivers in that country)

Easy to name, i.e. the object (and/or sign):

- Would only be given one (or two) names if all drivers in that country were asked to name it

Different to surrounding objects, i.e. the object (and/or sign) is:

- Unlike any others nearby

In practical terms (i.e. to justify inclusion in a navigable database) landmarks must also be as permanent as possible, however this is an issue of database reliability over time rather than navigation value at any point in time.

The important point to remember about the factors incorporated in these guidelines is that, if they are to be used as attributes assigned to database objects then, ideally, it should be possible to determine them without having to view the object directly. This is possible for certain categories of landmark. For example, assumptions can be made about the visibility or familiarity of groups of homogeneous objects such as petrol stations, traffic lights or large supermarket chains. This is not so straightforward with more heterogeneous objects such as shops or monuments. For this reason it is likely that, when landmarks are first incorporated in navigation systems it will be on the basis of assumptions about categories of objects rather than an individual object at a certain manoeuvre. A more 'tailored' choosing of landmarks can only be possible if that object can be viewed. At the moment this is not resource efficient for database manufacturers, but there are companies currently producing GPS-stamped video of portions of the road network so the future possibilities are there.

4 Driver reaction to good landmarks

A total of 48 participants, split into 3 matched groups, used a modified in-vehicle satellite navigation system to navigate around a complex urban route. The navigation instructions included either 'good' landmarks, 'poor' landmarks (based on the guidelines outlined in section 3) or distance information within the auditory instructions, depending on the participant group (i.e. a between-subjects experimental design was employed). Auditory instructions were provided at 450m (Preview 1), 200m (Preview 2) and 30m (Final). The participants were matched according to age, gender, self-reported distance judgement ability and self-reported navigation ability. The following driver behaviour measures were collected in real-time during the course of the trial: visual glance data via video recording; assessment of driving errors by an accompanying qualified driving instructor, assessment of navigation errors by an accompanying experimenter, and self-reported driver confidence at three points during the approach to, and once immediately after each manoeuvre.

Detailed statistical analysis was undertaken for all measures; these details are omitted from this paper, but where experimental effects are identified below, these were all significant at $p = 0.05$ or less (i.e. there was at most a 5 % likelihood that the observed differences were due to chance).

For the visual glance data, a percentage moving time metric was calculated based on the time spent glancing to the display as a proportion of the time spent travelling the 500m approach to a manoeuvre. The means for each of the three participant groups (good landmarks, poor landmarks and distance information) are shown in Figure 2. Mean driver confidence (on a scale of 1to3, low to high) at each auditory instruction point (Preview 1, Preview 2, Final) and immediately after each turning (Post) are shown in Figure 3 for the 3 participant groups.

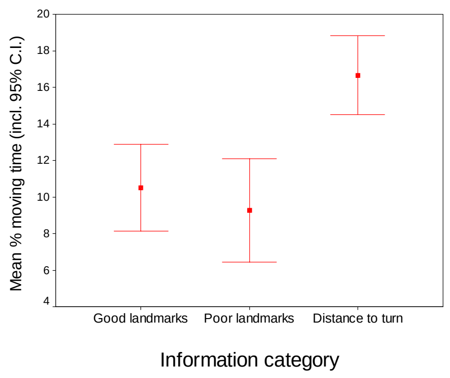

Figure 2. The effect of information category on the % moving time spent glancing to the display during the approach to a manoeuvre

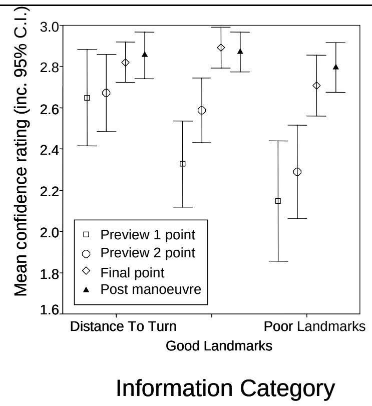

Figure 3. The effect of information category on the mean driver confidence (1='low'; 2='medium'; 3='high') at the Preview 1, Preview 2 and Final message points, and Post-manoeuvre.

Two main types of errors were analysed. *Driving* errors were coded into categories based on those used in the UK driving test, and assigned a value of 1, 5 or 10 according to whether they were minor, serious or dangerous errors. The difference in the aggregated error scores between the participant groups is shown in Figure 4. Figure 5 shows the difference in the *navigation* errors committed by the 3 participant groups.

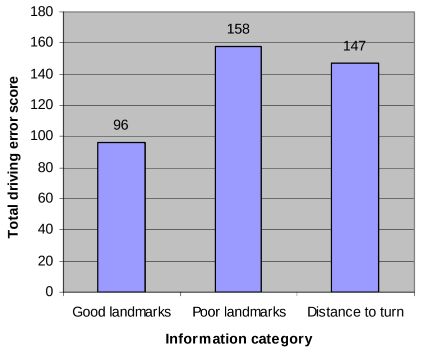

Figure 4. The effect of information category on the total driving error score per participant group

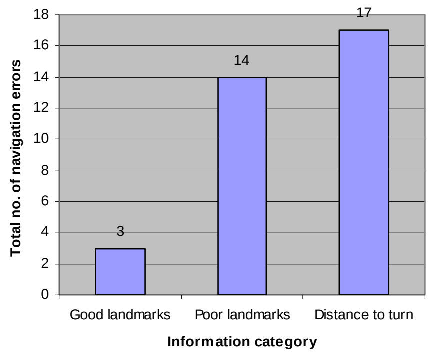

Figure 5. The effect of information category on the total of navigation errors made, per participant group

The main findings can be summarised thus:

- Incorporating landmarks within the verbal navigation instructions resulted in a 40% reduction in the percentage of approach time spent looking at the in-vehicle display. Some participants made *no* glances to the display during the approach to a manoeuvre when using instructions that included landmark information.
- Driver confidence at the beginning of the approach to a manoeuvre was higher when good, as opposed to poor, landmarks were used to locate turnings, but in general lower than when distance information was used instead.
- When good landmarks were used (as opposed to poor landmarks or distance information), fewer driving errors were committed by participants, consistent with the findings of Bengler et al., (1994), Philips, (1999).
- The use of good landmarks resulted in far fewer (actual or near) navigation errors than when poor landmarks or distance information were used instead.

5 Presenting landmarks verbally

In addition to identifying the attributes and context that make landmarks appropriate for navigating by, this would be pointless unless they can be presented effectively within a system, ideally (to minimise visual distraction) in auditory instructions. Although, there is theoretical value in separating navigation value and ease of presentation (the latter is dependent on technological possibilities and the former is not), the REGIONAL project also aimed to provide advice to the navigation industry on the most appropriate implementation of landmarks with *current* technology. Hence it was useful to identify the features of landmarks that make them easy to present verbally to drivers. The combination of a landmark that is both navigationally effective *and* easy to present will provide the best support for a driver. Words/phrases used to describe landmarks can be broken down into the following elements.

- Form (what it looks like), e.g. "large, white"
- Function (what it is), e.g. "church"
- Label (what it is called), e.g. "St Mary's"
- Location (in relation to the driver), e.g. "on the left"
- Reference (in relation to the required manoeuvre), e.g. "turn left after"

The raw data from the direction-giving studies reported in section 2 were analysed further to identify the verbal descriptions associated with each landmarks (classified according to the elements listed above). Descriptions varied widely in the number of elements required to describe them unambiguously, for example compare "turn right just after the large, white, Roman-looking building on your left" with "right after the church". Landmarks that require few elements (1 or 2) to describe them effectively will be easier to present in the primary, verbal message. From the analysis, it was found that such landmarks are likely to meet the following criteria:

- Have a visible label from the direction of approach
  (e.g. a petrol station logo that is designed to be seen by all approaching drivers)
- Conform to a stereotype of a form, function or label
  (e.g. a traditional church with spire, traffic lights)
- Have a familiar brand/label
  (e.g. the 'golden arches' of McDonalds™)
- Have no other similar objects nearby
  (e.g. a single bridge in a long stretch of road)

As discussed earlier, for several landmark categories (e.g. petrol stations, traffic lights), assumptions can be made regarding their match with these criteria without expensive site visits.

6 Data reliability

Evidence of the benefits of landmark inclusion were stated earlier but, also discussed, was the industry requirement that data can easily be kept up-to-date. Information on several categories of landmark will become inaccurate more rapidly than some other types of information (e.g. road geometry is fairly static as are road names). Equally, some categories of landmark will experience more frequent change than others (e.g. the names of public houses change frequently whereas church names rarely do). One solution to name changes is, of course to only use generic terms for all landmarks, e.g. 'public house', 'petrol station' but this would reduce the potential benefits of landmarks and their ease of presentation and could also be seen by industry as a retrograde step (fuel brand logos are already used to identify petrol stations on maps – as 'Points of Interest' data rather than as landmarks). It was important, then, for the research to at least begin to understand the effect that such database errors may have on drivers. Very little research exists regarding the (un)reliability of navigation information.

The study conducted within the project considered two commonly used categories of landmark: public houses and petrol stations (with traffic lights used as a control condition). Eighteen participants drove three routes, each route using one category of landmark within the navigation instructions (10 traffic lights, 10 public houses or 10 petrol stations). All 'target' manoeuvres (i.e. those using landmarks) were linked by several other manoeuvres without landmarks to ensure a continuous and realistic route. For the control condition, there were no errors. For public houses and petrol stations, the 7th landmark was given an incorrect name (i.e. a 10% error rate). Measures were taken of driver confidence at each manoeuvre (1=low, 2=medium, 3=high) and driver opinions. The results are shown in Figure 6.

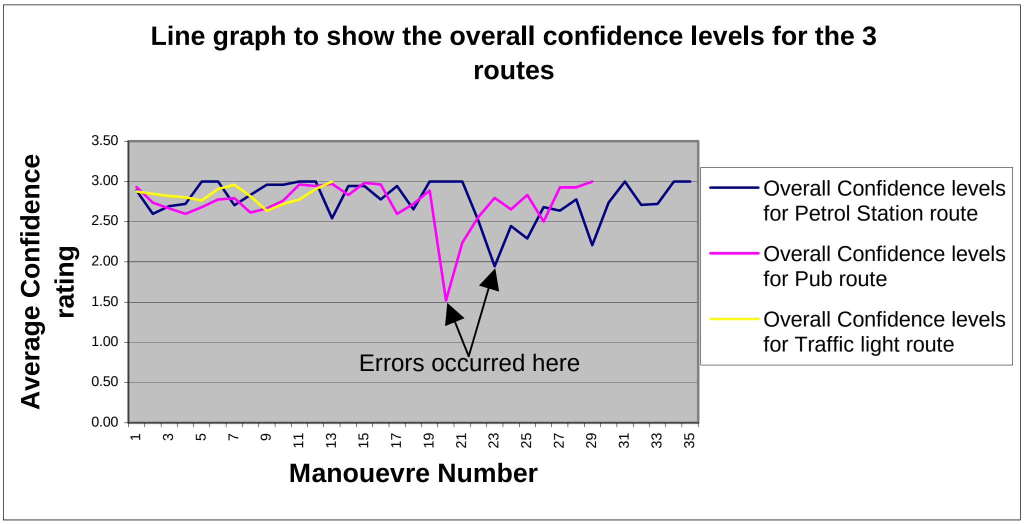

Figure 6. Changes in confidence due to errors in naming of landmarks

The most significant findings were:

- Prior to the error occurring, all categories of landmark induced a similar level of mean driver confidence (traffic lights = 2.83; public houses = 2.79; petrol stations = 2.85).
- Post-error, mean driver confidence dropped to 2.63 for petrol stations and only 2.29 for public houses
- After the error occurred, mean confidence did not return to pre-error levels until 3 manoeuvres later.
- Sixteen of the eighteen participants noticed the error in the public houses condition but only 9 (out of 18) noticed the petrol station error.

These results show that the same level of error will not always induce the same reaction from drivers. The effect of an error seems to be dependent on the category of landmark. The research found that the error for petrol stations was mitigated because they scored highly on the following factors (a sub-set of those listed in section 3):

- Easy to see
- Easy to spot/find

- Easy to pick out from its surroundings
- Is an object that a driver interacts with as part of driving
- Different to surrounding objects

It is these features of petrol stations (designed to be easily spotted by drivers, very different to surrounding objects, likely to occur singly) that were probably the influential effect in the study. When the petrol station was given the wrong name, half of drivers did not notice, and the remainder probably assumed it must be the right one anyway as there is not likely to be another in close proximity (drivers in the study were also provided with distance information). For public houses, more drivers noticed the error and were more unsure because pubs are often clustered together and can be difficult to pick out from the surroundings.

This very preliminary study resulted in some very interesting findings from which some generic conclusions have been made. However, further similar studies would be needed before the effects of errors in other categories of landmarks could be identified and the overall impact of driver confidence and performance assessed.

7 Conclusions

The main conclusions from the studies reported above are that objects in the environment that are: (i) useful for navigation, (ii) easily described in verbal instructions and (ii) mitigate any database errors will meet some, or all, of the following criteria:

- Visually prominent with a clear label
- Unique on the approach to that manoeuvre
- An object relevant to drivers
- Well positioned to assist the manoeuvre
- Have a stereotypical appearance
- Have a familiar brand/label

8 Future developments

So, some comprehensive research findings have been produced which can be valuable in determining requirements for future system enhancements. Considering the attributes of good navigational landmarks should be a major consideration in the development of POI databases. In addition the business case for landmarks can be strengthened if their use in other systems can be understood. For example:

- Some driving landmarks could also be suitable for pedestrian navigation (the influential factors identified by the REGIONAL research can be used as a starting point)
- Landmarks such as steep hills or sharp bends can be used for adaptive vehicle dynamics (e.g. torque vectoring or predictive shift-scheduling)
- Public and commercial facilities can be used as part of wider location-based services (e.g. find my nearest) to enhance navigation systems and other mobile devices.
- Public authorities and utilities and the emergency services may have specific requirements for data on buildings, street furniture or environmental features

The interesting development to come will be the convergence of in-vehicle and more truly ‘mobile’ systems and how they can be developed to provide true *value* to the user. Only by allowing people to achieve *new* and useful goals or by significantly enhancing the performance or convenience of their *current* tasks will the industry attract the market it seeks and the repeat revenue from these services. It is this aspect of predicting and measuring added value that is the next challenge for research.

9 Acknowledgements

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