

Compass Assisted GPS for LBS Applications

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BIOGRAPHY

Mark D. Amundson P.E. is the applications engineer for Honeywell Magneto-Resistive sensor products at the Honeywell Solid State Electronics Center in Plymouth Minnesota. He has worked on many new magnetic sensor products and applications for personal and vehicle navigation systems. Always in the pursuit of “better, cheaper, smaller”, Mark uses his RF and avionics background to assist customers in designing new sensor-based features into their next-generation products.

ABSTRACT

Location Based Services (LBS) has become the key feature for wireless phones, and its wheeled vehicle equivalent, Telematics. The essential elements to LBS have been a two-way wireless data communications link plus navigation data inputs to permit a screened flow of information from LBS data servers. Today, most LBS system designers consider the fusion of Global Position Satellite (GPS) receivers and cellular phone services the starting point.

Compassing is another navigation aid that LBS can use along with wireless services and GPS data. Compasses rely on sensing the earth’s magnetic field, and supply a compass heading angle based on a north heading reference. By assigning a wireless phone or telematics receiver a forward direction for pointing, the resulting pointing/heading angle is essential in LBS applications to indicate to the data server what you are pointing to. This paper is intended to show that magnetic compassing is a “must have” feature for quality Location Based Services functionality.

INTRODUCTION

Location Based Services are a subset of an ongoing trend to bring personal navigation information into the life of world-wide consumers and mobile business-persons. Up until the last decade, personal navigation was a map and a needle compass for scouts, hikers, pilots, boat captains, and soldiers. As the wireless phone became ubiquitous, and GPS receivers gained non-military usage; these first tools in forming LBS networks became available. Then the biggest remaining piece of the LBS puzzle is a group of competitive entrepreneurial companies to invest in the

server infrastructure, and find a model to profit from its usage.

Another trend that fits into the LBS picture is telematics. Like it or not, two-way voice and data communication is another driver distraction; with the honest intent to add pleasure to the driving experience by providing timely information to shorten the trip, and inform the driver of desired information along the way. While I was not born when broadcast radios were made available in cars, I am sure that radio-less drivers were both jealous and critical that broadcasts would make reckless drivers of all who listen.

Telematics is more than a cradle to hold your LBS-enabled phone while driving. Domestic and foreign auto manufacturers are rapidly designing in moderate-sized (about 8 to 10-inch diagonal) Liquid Crystal Displays (LCDs) into dashboards to display on-demand roadmaps, internet browsers, points of interest information, and especially Location Based Advertising to help pay for the LBS infrastructure.

GPS ADVANTAGES AND DISADVANTAGES WITH LBS

Since the removal of Selective Availability (SA) errors to GPS signals and the arrival of very good and very small L1 signal tracking GPS chipsets, GPS receiver data quality has improved enough for street-by-street discrimination of latitude and longitude. Today, you can integrate a GPS module that locks on to multiple satellites within seconds and gives you better than a 10-meter CEP (Circular Error Probability) fix on your position.

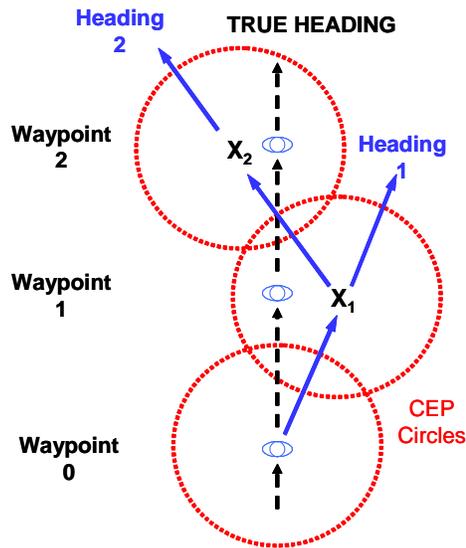
And now the new Qualcomm wireless phone chipsets come with built-in GPS RF and Signal Processing functions intended for E-911 location information, and riding on the existing 3G wireless voice/data system operating between the 800 MHz AMPS and 1900 MHz Digital RF bands. With only one RF section and the GPS/Phone demodulations all in one chip, the moniker “buy this phone and get GPS for free” is the silent marketing plan.

But GPS is not a perfect navigation experience either. Just like digital 3G reception inside of buildings at 1900 MHz, receiving GPS L1 signals at 1575 MHz gets very difficult when steel and concrete are between you and the three

required GPS satellites. Time To First Fix (TTFF) stretches from a second (out in the open) to tens of seconds, if you can get enough signal through the roof or side of commercial buildings. Even heavy tree canopies can occlude GPS signal reception, making GPS-based navigation less than a reliable experience without backup assistance.

While dead reckoning with quality (low-drift) yaw gyros can backup the last GPS waypoint fix, the backup eventually blooms the CEP to useless information. Even at 10 meter CEPs with GPS, Location Based Services are contingent on accurate pointing capability with accurate latitude and longitude.

Without a magnetic compass, LBS requires pointing to be done by a differential waypoint means. By choosing two fixes and subtracting the older from the newer, a predicted heading is established. Figure 1 shows this from an overhead perspective.



EXAMPLE: CUSTOMER WITH LBS PHONE WALKING

Figure 1

From the figure, the customer is a pedestrian walking in the straight line with a phone integrated GPS providing continuous waypoints/fixes over time. Because the waypoints have many meters of location uncertainty, heading error creeps into the predictions. And if the customer stops, rotates while stationary, GPS-based pointing becomes useless.

ENTER COMPASSING

When an electronic version of a magnetic compass is added to LBS and Telematic systems, the pointing task now becomes the responsibility of the compass circuits, and the GPS receiver is the backup system. While electronic compassing is prone to heading inaccuracy inside steel and concrete buildings, the errors will be smaller outside where most LBS will be used.

When GPS is unable to maintain the location, dead reckoning backup becomes feasible with a tilt-compensated electronic compass. The compass provides the direction from the last GPS waypoint, and the compasses MEMS accelerometers do double-duty by becoming a pedometer to count footsteps by the user. The error build-up in location CEP is dependant on quantity of footsteps, not with time, such as in inertial-based systems. Honeywell's dead reckoning algorithms are proven to have good location accuracies, from the initial phases of the Army's Land Warrior program.

LOCATION BASED SERVICES BASICS

To make a quality LBS experience, pointing accuracy must be moderate to precision-grade. Defining moderate accuracy heading errors as $\pm 2^\circ$ to $\pm 5^\circ$, and precision heading errors as less than $\pm 2^\circ$; these errors are important in being able to point to moderately distant businesses for product or service discrimination. Figure 2 shows the typical scenario in LBS pointing.

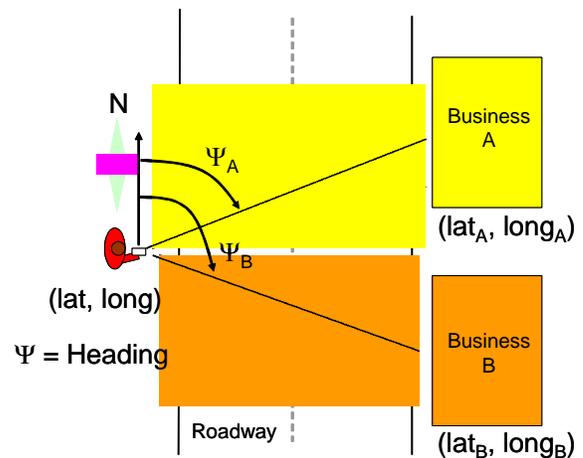


Figure 2

Location Based Services

In Figure 2, the ability to pick out business A from other surrounding businesses, the LBS servers need accurate latitude and longitude, plus an accurate heading. Then the nearest subscribed LBS business will appear on the customer's LBS enabled phone. When the distance between the customer and the LBS businesses is large, or when the businesses are densely packed together, then pointing (heading accuracy) is most important.

LBS APPLICATIONS

From the fledgling LBS and Telematics industry, several baseline applications have come forth as reasons for customers to acquire the services. The number one application, or “killer” application, is map display navigation and turn-by-turn navigation. Other applications of significance are person finders, business finders, and topographic map displays.

While LBS applications are compelling, not all users will be willing to pay monthly subscription fees for them. Multiple revenue models have been created, to bring the public into LBS/Telematics as consumers. Premium subscribers will pay monthly fees as additional charges for their phone service, and Telematics service providers will bill in a similar manner. These premium consumers will have access to all the applications with a minimum of Location Based Advertising.

On the other side, economy subscribers may not pay at all for LBS or Telematics, but receive basic mapping and points of interest features, and a healthy amount of Location Based Advertising to subsidize the free features. Just like yellow pages advertising, businesses will pay for advertising “screen time” as your phone or vehicle comes into proximity of their business.

TURN BY TURN NAVIGATION

As the killer application, turn by turn navigation is more than a map on the screen. The LBS/Telematic servers will also keep the maps plus continuous updates of weather, construction sites, and traffic congestion/accidents via the local Departments of Transportation (DoTs). So instead of just a fixed time arrival based on routes and speed limits, your arrival factors in the weather, congestion, and construction; and may even provide recommended detours for better arrival times.

And of course there is voice prompting of turns by the navigation software. But this feature is already available in a few brands of self-contained GPS vehicle navigation products. But instead of just male and female voice choices, a LBS server may be able to download customized voices, much as wireless phones have custom ringtones. Imagine voice caricatures of Don Rickles or Zaza Gabor or Homer Simpson advising you that you missed the last requested turn and have to turn around.

With an electronic compass the turn by turn application is further enhanced by allowing the map to display your current position at the bottom of the LCD instead of the middle, thus conserving precious display for what is in front of you instead of what you already passed by. Also a good compass direction and adaptive location map should always be “right reading” so that street names and numbers are never vertical or upside down on the screen.

The last feature of turn by turn navigation should be a handy list of personal locations, easily editable and capable of uploads and downloads with other consumer electronics. Things like appointment minders or electronic daytimers should seamlessly mesh with your itinerary to give you location to location estimates of travel times with traffic history estimation on arrival times. To plan a day’s appointments the previous evening with weather and construction predictions would be an admirable goal.

PERSON FINDERS

Just as you have a Microsoft Outlook “contacts” list, a LBS “buddy finder” could be an application that you could enable in your phone or on your vehicle. With your “buddies list” similarly enabled, tracking your spouse or children at the shopping mall or carnival can be done. In the same way, salesperson or coworkers can be made aware that they are in the vicinity of each other for a quick meet up.

Mapping your buddy locations should be customizable, as most individuals may not care about individuals out of a short walking distance, or maybe open up the range if on travel. Other options may be handy like “buddy blocker”, to hide yourself from your buddies, for when you are having a bad day and just want to be left alone, or for certain buddies that are on a temporary “persona non grata” list.

THE YELLOW PAGES

This is what Location Based Services means to most people. Besides the basic function shown in Figure 2, I will share two typical examples for LBS and Telematics.

Example one is the downtown lunch time scenario case were you point your LBS enabled phone to the restaurant across the street. The LBS server picks up your request and downloads the restaurant’s menu, specials of the day, links to recent restaurant food critic reviews, an e-coupon for an entre, and a prompt for an optional dinner reservation.

Example two is the outside sales trip down the rural interstate highway, and the vehicle’s Telematics system monitor’s the vehicle CAN-bus data stream, and notices that you are down to a quarter-tank of fuel. Knowing that your preferences list contains Chevron as a preferred service station chain, the in-dash display prompts you with upcoming Chevron service stations along the interstate, how far they are away, and what exit marker to take, and also the current fuel prices and notable amenities the service stations have. And of course, the Telematics screen has the good sense to only display the stations you could make with the remaining fuel in the vehicle.

These two examples show the classic push and pull of services and products that LBS can provide. The interstate example represents an automatic “push” of information to the customer based on location, direction, and customer preferences. The restaurant example is a customer “pull” decision to have more information of business immediately in front of him/her.

In a more “Yellow Pages” kind of example, a customer can data mine via LBS in different ways. Figure 3 shows a typical downtown map showing locations of all restaurants in the general latitude and longitude of the customer. By enabling an electronic compass of adjustable precision, the customer may narrow the request by asking for “all Asian cuisine in this direction”, and point the phone. Figure 4 shows the results of a compass-aided search.

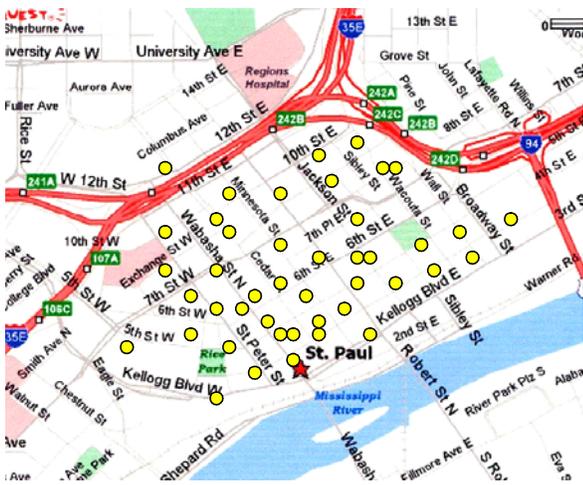


Figure 3
All Local Restaurants

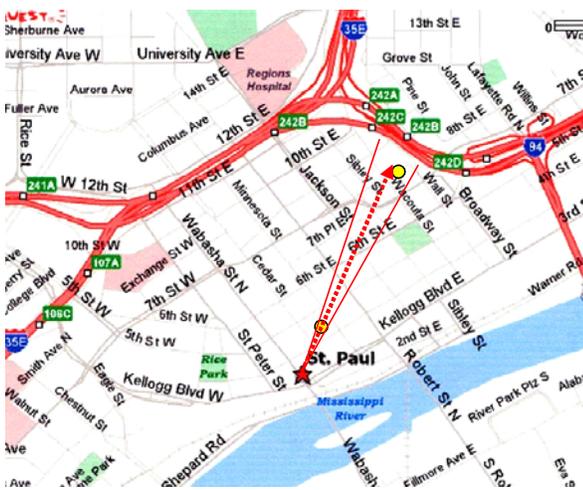


Figure 4
Asian Restaurants in That Direction

SPORTING MAPS

Good LBS could provide topographic style maps for outdoor functions as long as the wireless service provider can support the communications. As with turn by turn navigation, the compass keeps the map right reading and shows the terrain up ahead, like a broad beam flashlight, to best make use of the limited size LCD screen.

And like a good GPS unit, customers can mark personal waypoints and annotate personal points of interest for use after the trip. But unlike most handheld GPS receivers, the handy LBS server becomes your instant natural resources guide by providing geographic history, points of interest, near-term weather forecast and current conditions.

TAKE HOME MESSAGE

Location Based Services and Telematics applications are going to revolutionize the way we travel and socialize with the incorporation of personal navigation and information services. Already deployed in much of Asia, most of the younger citizenry consider their LBS enabled phones more of a personal appliance with a phone feature, instead of a phone with options. And these fashionable youngsters consider their personal handheld device a fashion statement, much like we Americans choose and customize our vehicles.

The electronic compass in LBS and Telematics becomes more of a “pointer” to narrow the selection of information like nearby products and services. However, the quality of this pointer is described as compass accuracy in degrees. Some Asian manufactures may play the “disruptive technology” card and offer poor quality magnetic sensors with words like “direction sensor”; but a quality electronic compass with tilt compensation can be a useful for GPS dead reckoning backup, besides a moderate to precision pointing device.

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