Glow Tags: The Choice of the Old Generation

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Abstract

Memory loss, both long term and short, has always been a problem for the average human being. Given this and the amount of people with memory degrading illnesses in todays world, over 38000 people with dementia in Ireland today, with an estimate of 100,000 people by 2036[13], there is a need for new technologies to be developed to aid human memory. One big problem for people with illnesses such as dementia and Alzheimer's, is forgetting how to get from point A to point B (e.g. getting home from the shops). Such forgetfulness can happen very easily and can lead to confusion and panic which in turn can lead to injury. We propose a prototype "Glow Tag" (GT) device, leveraging UCD's multi-modal positioning infrastructure. The tag will accept a path as an itinerary of beacons, and will "glow" in the direction a user must travel in order to reach the next beacon, until the destination has been reached, hence acting as a subtle memory aid in way-finding.

Keywords: Way-finding, Embedded Computing, Low-Level Hardware, Gumstix, Location sensing

1 Introduction

One of the most interesting aspects of the human brain, or indeed to be more specific, the mind, is memory. How are facts, sensations, and events stored, arranged, and retrieved? And how can memory be so delicate that it can degrade so easily? Forgetting where you put your keys, whether you took your medication or not, how to get home from the shops, all very mundane things for young people but as people grow older, or are stricken by memory degrading illnesses these simple tasks become a lot more difficult. Only now with the dawning of new scientific disciplines such as Neuroscience and Cognitive Science can we even begin to comprehend these processes, and try to use technology to improve them.

Over the past decade there have been many advances in memory aids for people suffering from memory problems. Much research has been conducted into the use of electronic memory aids (EMAs)[4, 5, 6] as can be seen in the work done by *Oriani et al.*[2] on the use of EMAs with patients suffering from Alzheimer's disease, as well as *Kaupur et al.*[3] who review the application of EMAs for enhancing the memory functionality of patients with non-progressive brain injury and those with mild or moderate memory deficits. All research into the area of EMAs indicate that there are advantages in using EMAs, but that there is a need for more EMAs that are cost affective and both easy and intuitive to use. This is crucial in encouraging patients to use EMAs.

One part of memory which has the potential for improvement is short term memory, or in specific *working memory*. Working memory is the collection of structures and processes within the brain used for temporarily storing and manipulating information. This temporary storage has a limit capacity for information[7], this limit varies from individual to individual[8] but is thought to be in the region of 7±2 pieces of information. One limitation of this, is the ability to receive complex instructions or directions. This reduces a person's ability to navigate new environments, or in the case of people with memory deficits, navigate old environments as well, without the help of some sort of memory aid.

The aim of this project is to explore the development of an intuitive, easy to use EMA that will glow in the direction that a person needs to travel to get to a specific destination.

2 Directional Assistance with Glow Tags

The concept of a GT was first suggested by Isaac Asimov in his novel "Foundation"[1], where the protagonist is handed a ticket which glows in the direction in which he is meant to travel. Our GT system is based on the same basic principal, a small hand-held navigational device that reads in a virtual representation of the surrounding environment, figures out your position within the same environment and constructs a path made up of waypoints of the shortest route to a predefined destination. The system then glows in the direction of the next way point until the destination has been reached.

Location based services and ubiquitous computing are becoming more and more prevalent in todays world. *Griswold et al.*[9] showed how successful location based services implemented through out an entire campus can be, and what the implications of this are. The GT system can give students a novel and intuitive way to navigate across campus and inside new buildings to find classes or colleagues. Taken away from the realm of the academic, the GT system could greatly aid people with short term memory deficiencies in getting from place to place, not to mention be used as a guide to anyone in an environment that is unfamiliar to them.

The system itself is constructed from three core elements, see Fig. 1, a central processing and storage unit (CPU), a real time location system(RTLS), and an output interface. The CPU is used to gather the positioning data from the RTLS, to do computation based on this data, and to produce an output to be interpreted on the output interface.

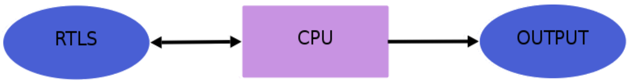
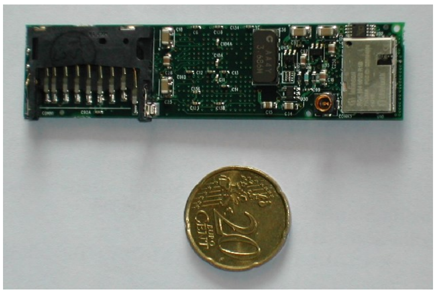
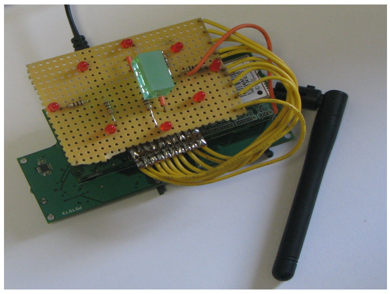


Fig 1. Glow Tag Process Chart

For the CPU a Gumstix Computer[14], Fig 2(a), was decided upon. Gumstix are tiny Linux embedded computers about the size of a small mobile phone with bluetooth, Wireless-LAN, and GPS. Utilising UCD's multi-modal positioning infrastructure, Ubisense was chosen as the RTLS for the prototype, with future trials to be held using GPS depending on how successful Ubisense proved to be. The output interface was custom made in the form of a LED compass, with an LED at each of the eight points to indicate direction, and one in the center to indicate important events such as reaching a way point, or the destination.



(a)



(b)

Fig 2. A Gumstix Computer & The Glow Tag

2.1 System Design

The device CPU uses the RTLS to obtain the GT's position in 3D space, and cross references this position with a 3D map stored on the CPU to determine its location in the environment. Then using the A* algorithm[15] the CPU calculates the shortest path between its current position on the 3D map and a predefined destination. This algorithm returns a path of coordinates, and along with the orientation of the user, it allows the CPU to calculate the relative angle of rotation that the user would have to turn in order to face the next coordinate/way point, lighting up the correct LED on the output interface to indicate the needed direction change.

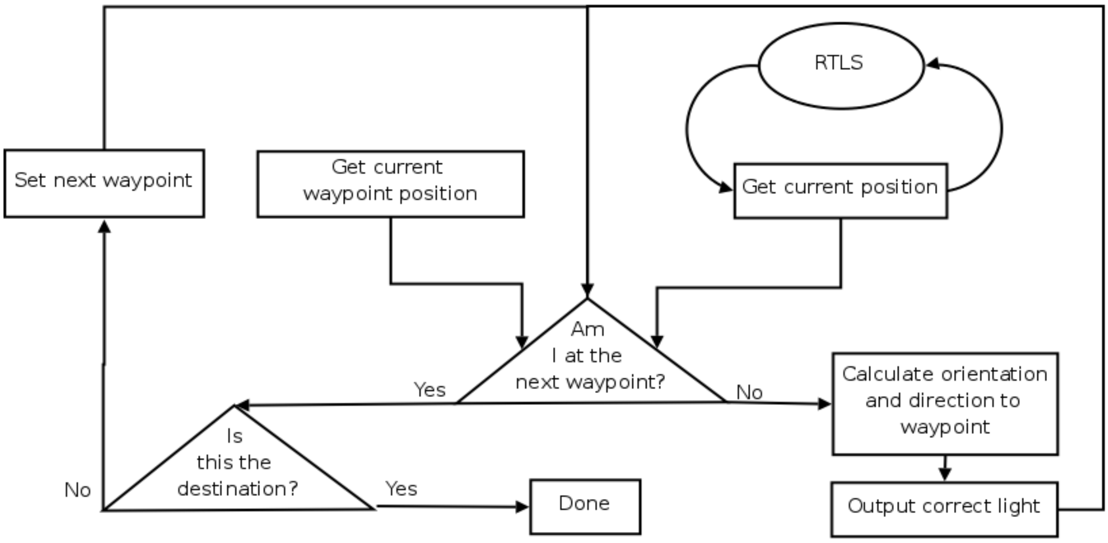


Fig 3. Detailed Glow Tag Process Chart

2.2 Location Detection with Ubisense

Ubisense is a RTLS utilising a radio frequency technology called ultra wide-band (UWB) to track objects accurately. Ubisense claim that accuracy of up to 15cm in 3D can be obtained[11], and work is currently in progress to test this in our installation[10]. The system itself is similar to all most other tag tracking systems, and consists of three parts, the Ubisense tags (tags), which are tracked, the sensors, which do the tracking, and the central Ubisense server, which uses the data collected by the sensors to triangulate each tag's position in 3D space.

2.2.1 Smoothing out the signal to allow for accurate tracking

While experimenting with Ubisense it was noticed that not only did the system have trouble getting the exact position of a tag, i.e. the position of a tag reported by the system would vary mostly by up to a meter, also sometimes it would miscalculate the position by anything from 1 - 10 meters and sometimes even more. This was not however very often, only about once every hundred readings or so.

In order to compensate for this, two smoothing methods have been employed. First, a threshold for the small inaccuracies: the tag must move a certain distance from its last accepted position before a new position is accepted. After much trial and error it was concluded that a value of 0.2m or 20cm gave the best results.

For the larger but less frequent inaccuracies the same technique can not be used since if the tag is moving quickly then all of the new positions will be ignored. So rather than this approach, a threshold value of 0.7m is used, but is not checked against the distance traveled, but rather the difference between the distance traveled this reading and the distance traveled the last time it was calculated.

```
while ( notTimedOut )
{
  currentCoord = getNextCoord();
  if ( distanceTraveled -  lastDistanceTraveled < MAXDISTANCE )
  {
    if ( distanceTraveled > MINDISTANCE )
    {
      lastDistanceTraveled = distanceTraveled;
      return currentCoord;
    }
  }
  else
    lastDistanceTraveled = distanceTraveled;
}
```

Fig 4. Pseudo Code of Filtering Methods

This allows the filtering out of the infrequent large in accuracies, granted one reading will be lost every time the speed of the tag increases significantly, but the once the speed doesn't fluctuate immensely then this should not be an issue.

2.3 Wayfinding in a 3D environment

In its simplest form, wayfinding is the ability to figure out how to get from one place to another. In order to use a technological aid to help navigate the physical environment a virtual representation of this environment is needed.

2.3.1 Calculating orientation

Calculating accurate positions of each tag is essential to being able to track the movement of each tag, and to calculate the orientation, i.e. heading of the tag. Without the aid of a compass or accelerometer this is impossible while the tag is static, i.e. not moving, since the heading is calculated using the tags velocity. Also to try and increase accuracy rather than just getting the velocity between the current position and the last position recorded, if an average velocity over the last few readings is taken, see Fig. 5, then this helps to get rid of any small inaccuracies that were missed by the smoothing algorithm.

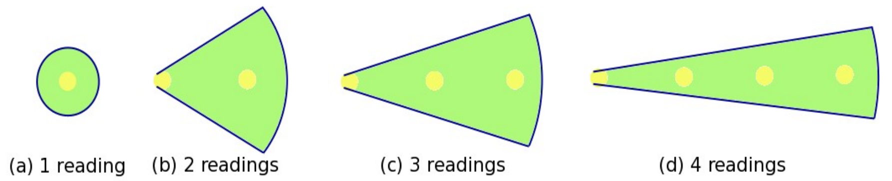


Fig 5. Calculating a tag's orientation

2.3.2 Lattice Graph representation of 3D environment

Encapsulating the environment in a graph provides a simple and intuitive way to represent the world around us. Mapping each junction and entrance as a node with a 3D coordinate attached to it. And edges representing paths between these points. Reducing the surrounding physical environment down to a graph allows the use of well known and refined graph traversing and searching algorithms, as well as the ability to plot routes very quickly.

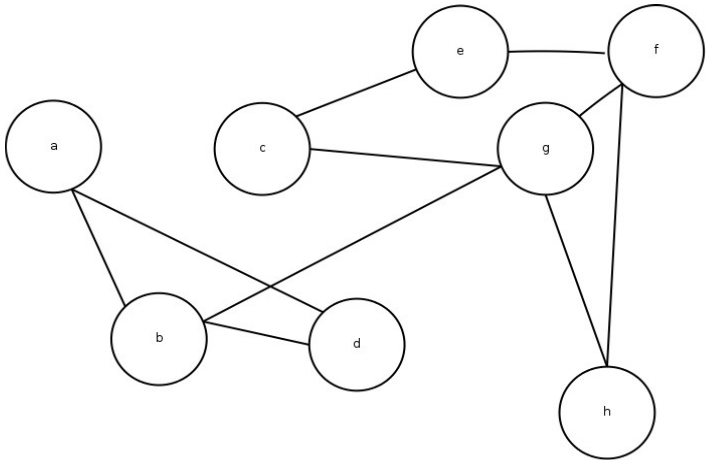


Fig 6. A lattice graph representation of a 3D environment

2.3.3 Shortest Path between two points

There are many ways of finding the shortest path between two nodes on a graph, there is one however that is used most commonly in wayfinding in computer games in particular, allowing computer controlled characters to move from location to location in a 3D environment. This algorithm called A*[15] (pronounced "A star"). A* is whats know as a best-first algorithm, meaning it attempts to decide which nodes have the best chance of being on the path next and looks at them before any of the others. A* accomplishes this by using a heuristic in addition to the length of each edge and however “difficult” this edge is to traverse, see *function f(),* Fig. 7.

```
class Node
{
  function f()
  {
    return g() + h();
  }

  function g()
  {
    return distanceAlongPathFromStart;
  }

  function h()
  {
    return sqrt( abs( x-goal.x)^2 +  abs( y-goal.y )^2);
  }
}
```

Fig 7. How A* estimates node search priority

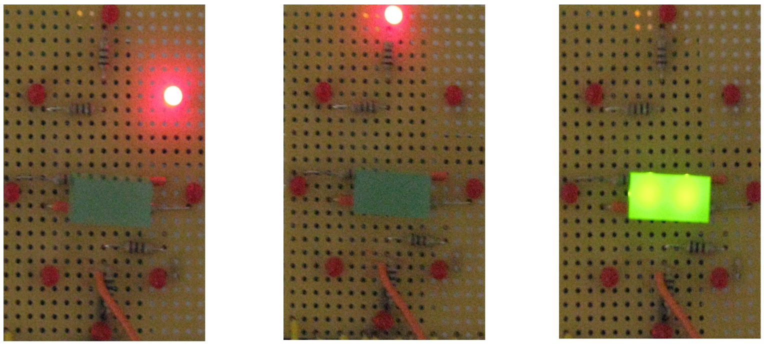
2.4 System Interaction

The more complicated and difficult a device is to use the less likely it is that people will want to use it. Since the nature of this device is so that it should be usable in a panic as well as under normal circumstances, the way users interact with the device needs to be very clear, simple and intuitive. Not only will this help the user understand what the device is telling him/her, but its simplicity will increase the appeal of the device.

2.4.1 Design of the output

One of the simplest and most intuitive designs for a navigational device is a compass, so for the GT eight LEDs were used, laid out in a circle with one on each point of the compass indicating a particular direction in which to travel in, along with a single LED centered in the middle of the device to indicate special events to the user, such as reaching a way point or the destination.

In Fig. 8 (a) below, the GT indicates that the user is traveling in the wrong direction, the user should really be traveling approximately 45° to the right. In Fig. 8 (b) the user has corrected his orientation and is traveling in the correct direction. In Fig. 8 (c) the user has reached the destination.



(a) Going the wrong direction (b) Going the correct direction (c) Reached the destination

Fig 8. Wayfinding Using the Glow Tag

2.4.2 Controlling the output

With the use of the Gumstix computer as the CPU and our configuration of gumstix expansion boards (Wireless-LAN and GPS) we had a limited number of options for driving an output device. The simplest of which was by using the LCD headers of the Gumstix processor, the Intel PXA255, as General Purpose Input/Output (GPIO) lines. This enabled control of up to twenty GPIO lines and makes the lighting of an LED as easy as writing to a file.

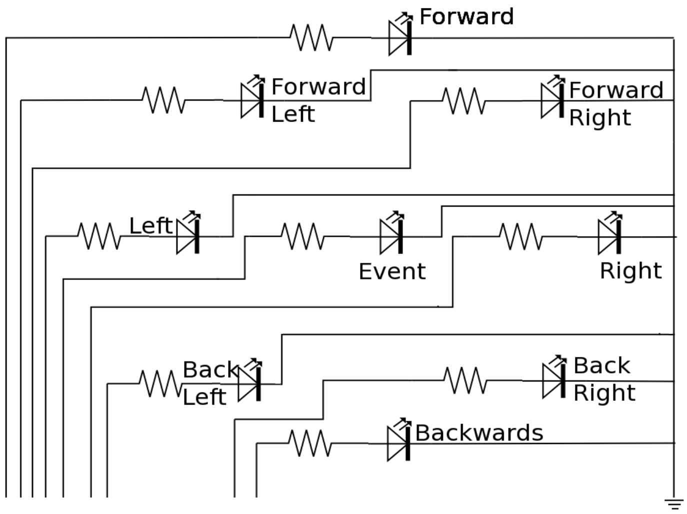


Fig 9. Schematic of the Output Device

3 Conclusion & Future Work

As a result of this project I have built a working GT and proved that the concept is definitely viable. The device, built on top of a Gumstix computer, can successfully receive locational data from the Ubisense RTLS, process this data and extract the users orientation, and using a 3D map of the environment build a path from its current location to a predefined destionation, calculate the angle to the next waypoint along the path, and output this information to the user in the form of a glowing light in the direction of the next waypoint.

EMAs are extremely useful, and have been proven to work[2]. There has not, however, been enough research conducted concerning all of the implications and advantages that they could have. This is why continued research in this field is important. This type of device can, however, be very helpful not only to people with memory deficiencies and illnesses such as dementia and Alzheimer's disease, but also to anyone who needs to navigate through an unfamiliar environment.

In the short time that this project was undertaken there was enough time to create a working prototype but this is only the first step in the development of the GT, there is much future work to be completed to improve the device. The addition of GPS, electronic compass, and accelerometers are major advancements that would allow the merging of RTLSs and the seamless transition between internal and external environments while using the device, not to mention increasing the accuracy and usability of the device.

In order to evaluate the intuitiveness of the GT, an intensive user study will be undertaken, comparing the GT with other navigational aids, in a variety of scenarios. This evaluation will compare the GT with the two most common means of pedestrian wayfinding, a GPS equipped PDA, and verbal instructions. The first method of comparing these aids is for the users to navigate between two distant points (A – E) across an unfamiliar environment using each method. Secondly is to repeat the exercise with the addition of providing waypoints to travel along (A – B – C – D – E), and to see which of the three means of navigation was most successful. The third method is to repeat both previous processes but require the users to navigate through buildings as well. Finally the time taken by each device to complete each trial, and the distance traveled will be assessed, as well as how intuitive and easy each device is to use.

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