

Independent Indoor Navigation for Individuals with Memory Loss

Literature Review

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Table of Contents

Introduction.....	2
Dementia.....	2
What is Dementia?.....	2
Impacts of Dementia.....	4
Problems Facing Caregivers of Dementia Patients.....	5
Indoor Navigation.....	5
Difficulties with Indoor Navigation.....	5
WiFi based Indoor Navigation.....	6
Shortest Path Problem.....	8
Dijkstra’s Algorithm.....	9
Conclusion.....	9
Works Referenced.....	11

Introduction

Patients with dementia often have to face problems in their daily lives for things that most people would find trivial due to the disease impacting their mental faculties. These problems typically cause issues for not only the patient with dementia, but also the people that would have to take care of the patient. One of the problems that dementia patients face is with navigating through buildings. Patients suffering from dementia often do not have the mental faculties to be able to remember the layout of a building and remember how to get from one area to another. This leads to a caregiver being required to be with the patient at all times because the patient could potentially wander off and get lost, which can be especially dangerous as most patients facing dementia also face other ailments due to old age.

Dementia

What is Dementia?

Dementia is the overall term used to describe different diseases and conditions that cause progressive and irreversible decline of different mental functions (Heuvel, 2012). These diseases and conditions are typically caused by abnormal changes or damage to brain cells and is not a normal part of aging (National Institute on Aging, 2019). These changes can cause improper communication between brain cells, which causes many mental faculties, such as thinking, behavior, and feelings, to be affected abnormally. Due to the brain having many distinct regions that are responsible for different functions, different forms of dementia are associated with damage to different parts of the brain. An example would be how Alzheimer's disease, which is one of the most common forms of dementia (Mayo Clinic, 2019), starts with

damage to the hippocampus, the learning and memory center, which is why one of the earliest symptoms of Alzheimer's disease is memory loss (Alzheimer's Society, 2013).

Because of the wide ranges of dementia, there is no test currently to determine if someone has dementia. Typically, dementia is diagnosed by looking at a patient's medical history, giving a physical examination, and looking at daily characteristics, such as normal emotions and behaviors, that have changed. These methods help doctors diagnose patients with dementia accurately. However, finding the exact type of dementia is much more difficult due to the overlap of symptoms with different forms of dementia. In some cases, a doctor might be able to identify that a patient has dementia but cannot determine which form of dementia the patient has. This would require a neurologist or gero-psychologist to diagnose the specific form of dementia (Alzheimer's Society, 2013).

The treatment for dementia varies in most cases due to multiple factors that influence the patient. However, for most progressive forms of dementia, there is no cure or treatment that slows or stops the disease from spreading. Instead, treatment primarily focuses on lessening the symptoms of dementia through the use of drug treatments that can temporarily lessen the symptom for patients (Alzheimer's Society, 2013). An example one of the common drug treatments would be cholinesterase inhibitors, which is a class of drugs that prevents the breakdown of acetylcholine, an important chemical for learning and memory. These types of drugs are typically used for moderate stage memory loss, and generally only have mild to no side-effects, which is why it is used.

Impacts of Dementia

Even though dementia comes in different forms, patients that suffer from different forms of dementia still face similar problems in their day-to-day lives. Normal things, such as preparing meals, keeping track of items, such as keys, and remembering appointments can be hard or even impossible for certain dementia patients. Patients with dementia often have less control over their lives and have to rely on caregivers or other people in general in order to live. In the research article by Gilmour and Huntington (Gilmour, 2005), researchers interviewed several memory loss patients, and found three major themes that were shared by the patients. These three themes were coming to terms with their memory loss, trying to maintain control and independence in their lives, and the impact that the illness has on their relationships.

Coming to terms was one of the major themes because many patients faced an increase in anxiety and depression after learning about their disease. Trying to maintain control and independence occurred due to patients having to rely on other people. The impact on their relationships occurred for several different reasons, such as in extreme cases where patients can forget the names and faces of close family members.

Due to dementia typically being a progressive disease, these symptoms often get worse as time passes, and can even be fatal in some cases. In certain forms of dementia, such as with Alzheimer's, the slow destruction of brain cells can lead to death because the brain can no longer do its required functions (Alzheimer's Society, 2013).

Problems Facing Caregivers of Dementia Patients

Dementia not only negatively impacts the patients that face dementia, but also the caregivers that have to take care of dementia patients. Typically, these caregivers are friends or family members of the patient, and they often have to provide 50 or more unpaid hours every week in order to take care of them. In the case of Alzheimer's, a majority of caregivers are the spouse of the patient and are therefore typically a member of the older generation. These caregivers are typically older than the average caregiver, such as with parents of children with disabilities and family members of accident patients. Because of this, when compared to caregivers for patients with other types of diseases, looking after someone with dementia takes more hours every week and has a larger impact on both the physical and mental health of the caregiver. It has even been shown that caring for a person with dementia has an increase in mortality for the caregiver (Huevel, 2012).

In a research article that attempted to determine major problems facing both caregivers and dementia patients, a group of caregivers were asked to respond to problems they normally face as a result from taking care of a dementia patient. Of the 31 respondents to the problem of patients wandering or getting lost, 20 caregivers responded that getting lost or wandering is a slight problem to a big problem (Huevel, 2012).

Indoor Navigation

Difficulties with Indoor Navigation

Indoor navigation systems often have unique problems when compared to other forms of navigation due to the difficulties caused by an indoor space. With outdoor navigation, for

example, GPS (Global Positioning System) relies on satellites to accurately pinpoint a user's position. Due to GPS being well established and widespread, it has become a reliable form of location tracking for outdoor navigation (Tsirmpas, 2015), however, GPS is not reliable form for indoor navigation. Problems that face indoor navigation, such as walls that block/distort signals, multiple floors that overlap, varying layouts for different buildings, etc, often cause GPS to become inaccurate in indoor spaces. This makes it an unreliable system for indoor navigation, and other methods would need to be implemented to improve accuracy and reliability.

WiFi based Indoor Navigation

Because GPS is unreliable for navigating in indoor spaces, other systems need to be used to overcome problems caused by having to navigate inside a building. One system that could be used is navigation with WiFi. WiFi is a form of local area network that is able to connect different devices in a small area with the use of radio waves. Because WiFi cards and access points already have the function of measuring the intensity of radio waves, devices such as phones and laptops can have distances from the source of WiFi be calculated (Xia, 2017). These distances can make it possible for an exact location to be calculated based on trilateration (Bell, 2010).

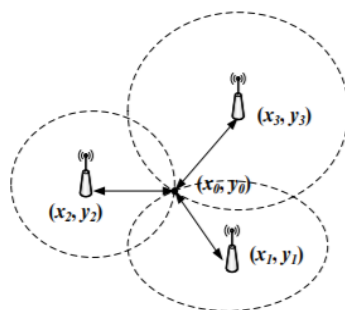


Fig. #1: Trilateration (Xia, 2017)

Trilateration is the typical form of positioning technology that has been applied to indoor navigation (Xia, 2017). It does this by getting the position of an object based on the relative distance of other objects. This is demonstrated in Figure 1 (Xia, 2017), which demonstrates how the intersection of three circles, with the center points being the towers and the radius being the distance from the source, can be used to find the exact position of the source. Trilateration is often paired with one of two positioning technologies, TSARS based or RSS based.

Time and Space Attributes of Received Signal (TSARS) uses the time and space of received signals directly to calculate the spatial distance. It does this by calculating the time between messages and the different angle of arrivals between messages. This data is then used for trilateration to find the exact position of the source device. This method comes with many major drawbacks, however. In order to achieve an accurate position, at least three access points are required, and additional hardware might be necessary. This can lead to a high development cost. Additionally, factors that interfere with radio frequencies, such as human body interference, can create difficulties in measuring the signal. Because of these drawbacks, RSS has been the main focus of study for navigation (Xia, 2017).

Received Signal Strength (RSS) based technology uses the strength of the signal in order to determine the position of a user. Unlike TSARS, no additional positioning system is needed. In addition, it is highly accurate, it does not require a huge amount of energy, and it is low-cost. These advantages have attracted a large amount of attention to this form of technology.

Shortest Path Problem

The shortest path problem is the problem of finding the shortest path between one vertex and another (Black, 2019). The shortest path problem is useful in situations where multiple paths from point A to point B are given, but a minimum distance is needed, such as with navigation.

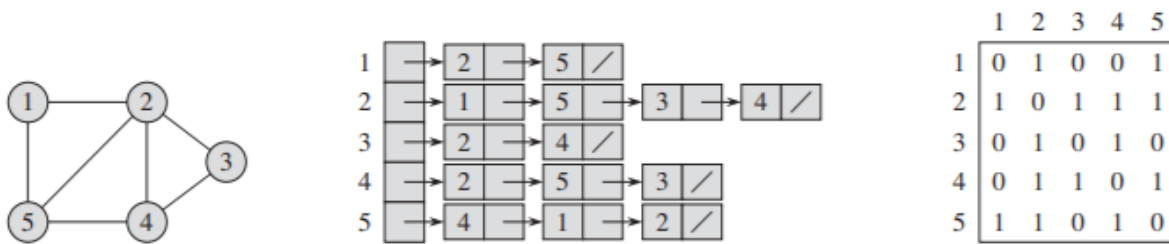


Fig #2: Different types of undirected graphs (Cormen, 2009)

Different representation of undirected graphs (paths that can be moved forward and backwards) can be used to interpret the shortest path problem. The left graph in Figure 2 (Cormen, 2009) is a visual depiction of the network, where you can only go directly from dot to another dot if there's a line connecting them. The middle image represents the same graph by having each blank box represent the dot based on the row, and numbers that an arrow point are points that are connected. The third image is a matrix of different combinations, where a 1 represents that the two points are connected (Cormen, 2009).

These graphs, however, can become complicated when adding in more factors, such as different distances between points, paths that only work in one direction, paths that loop back to the original point, etc. Because of these complications, algorithms have been developed to solve the shortest path in accurate and efficient ways.

Dijkstra's Algorithm

Dijkstra's Algorithm is an algorithm that has been developed for solving shortest-paths problems (Cormen, 2009). It does this by finding each path to a specific node and assign each of these paths a weight, which would depend on the length of the path. It would repeat this process until it determines the shortest path required to reach different nodes. These weights could be used to find between different subpaths from one point to another, and then find the shortest path. This is because the subpath of the shortest path must also be a shortest path (Yan, 2014). For example, if the shortest distance from A to D is $A \rightarrow B \rightarrow C \rightarrow D$, then the shortest distance from A to C is $A \rightarrow B \rightarrow C$.

Because Dijkstra's Algorithm is a uniformed algorithm, it does not need to know a large amount of information. This causes the algorithm to not need a specific target node and it can work with multiple target nodes. This happens because the algorithm already starts with finding every path combination to a node. However, a major drawback of the algorithm finding each path to a node is that it also wastes time finding longer branches that are not close to the target node. This occurs because the tradeoff of having a greater amount of flexibility and less information being required is that it is unaware of how close it is to the target node. Even with this tradeoff, Dijkstra's Algorithm is still a great algorithm for finding the shortest path between points in which distances are positive (Cormen, 2009).

Conclusion

Dementia is a wide variety of different diseases and conditions, but common symptoms patients face, such as memory loss, make it difficult to navigate in buildings. This leads to a

caregiver being required to stick with a patient because the patient could wander off and get lost, which is especially dangerous as most dementia also face other ailments due to old age. By using indoor navigation to help lead patients with dementia through buildings, it can improve the lives of not only the patient, but also their caregivers.

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