

# Drone Functional Service System for Dementia Seniors in the Aging Society towards the Innovative Safe Welfare

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DOI < 10.26821/IJSHRE.8.7.2020.8705 >

## ABSTRACT

*The paper proposes the drone functional welfare service system for the dementia seniors and their protectors utilizing drones and big data in South Korea, which has entered an aged society at a rapid pace. To solve the problems of dementia seniors being exposed to danger and protectors with increased stress, it recommends that devices identify the real-time location of the dementia senior and the protectors and that the police station provide services that enable the drone to be dispatched and situation-sharing if desired. Based on the statistics of police stations and the data of senior citizens in Seoul Metropolitan Area, it automatically analyzes the possibility of drones appearing when the senior is out and comes within the danger zone radius. The research may contribute to the nation for providing dementia seniors with reducing the missing probability and for providing their protectors with more personal social works and leisure in an aged society, and for increasing the performance efficiency of police administrations. Furthermore, the proposed solutions will expand the scope of the target with safety services to socially disadvantaged people such as children, the seniors and the disabled, which will increase the overall effectiveness of the social safety.*

**Keywords:** Dementia Senior, Aged Society, Welfare, Real-Time Location, Drones

Hyojin Choi; Serim Byeon; Youngsin Lee; Suyeon Kim; Yoo-Jin Moon, Vol 8 Issue 7, pp 34-42, July 2020

## 1. INTRODUCTION

Dementia is a comprehensive term that refers to a state in which memory-oriented cognitive impairment caused by brain damage hinders one from maintaining the previous level of daily life [1]. Also, it creates a complex symptom in which the normally mature brain is damaged or destroyed by a foreign person, e.g. acquired trauma or disease, which generally reduces one's intelligence and cognitive and mental functions.

Currently, there are 50 million dementia seniors worldwide and the number is expected to triple to 150 million by 2050. The number of dementia people in South Korea is gradually growing with 750,000 in Figure 1, far more than the Jeju provincial government's population with around 690,000 [2]. Dementia seniors are exposed to dangerous situations such as walking outside of their home alone when their protectors cannot take care of them [3].



system that includes advanced security drone patrols and emergency call reception system. Also, this will have great savings in the police work in the aspects of police personnel and budget.

The researches [12, 13, 14, 15] prove the feasibility and efficiency of using drones. The drones have been distributed to local police stations and hospitals, which is ineffective for safety of vulnerable people, budget saving and efficiency of police work. Thus, they already have police and hospital personnel who can operate drones.

The research is different from the previous studies in that it targets the dementia seniors. The ultimate aim of the research is to provide the effectiveness for the dementia seniors and expand the scope to children, the senior, women and the weak.

The sources of big data used for the research are as follows.

First, the research uses the Seoul Metropolitan Government statistics on welfare facilities for the seniors in Jungrang-gu, Gangseo-gu, and Yeongdeungpo-gu, which have the most senior welfare facilities in Korea.

Second, the dwellings in the above three districts are selected from the map to enter the latitude and longitude of the seniors' residence. Similarly, streets and buildings within the three districts are selected to enter the real-time latitude and longitude of the seniors.

Third, sex offender notification websites and TAAS traffic safety maps are used for open data in dangerous areas [16, 17]. The latitudes and longitudes of sex offenders living in the three districts are entered. The TAAS traffic safety map identifies the location of the pedestrian accident area and enters the latitude and longitude of the area.

Fourth, locations of the district, police stations and security centers located in three districts are confirmed through the Seoul Metropolitan Police Agency's information on the police station's data [18]. Five police stations located in the east, west, south, north and center of the district are chosen and their latitudes and longitudes are entered as data values.

The above four data sets are used to organize the data for this research and produce useful results.

### 3. SYSTEM ARCHITECTURE

#### 3.1 Entity-Relation(E-R) Diagram

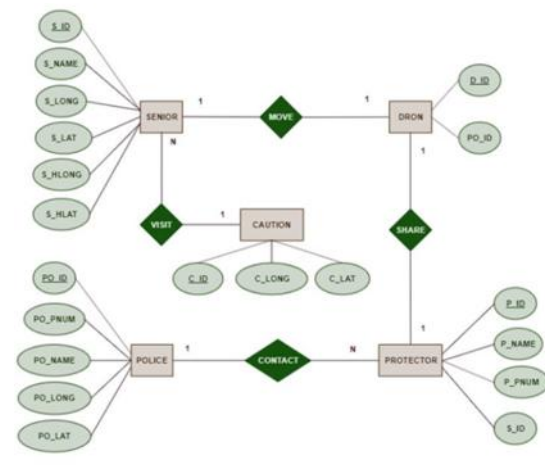


Fig 3: E-R Diagram for Drone Functional Service

The composition of the E-R diagram of the drone service database system is shown in Figure 3.

The E-R diagram expresses the movement relationship of the drone and dementia senior entity, the contact relationship between police and protectors, the sharing relationship between drones and protectors and the visiting relationship between the senior and dangerous areas.

The SENIOR entity has six attributes, which consist of the senior id (S\_ID), the name of the senior (S\_NAME), the real-time senior latitude (S\_LAT), real-time senior longitude (S\_LONG), and the latitude (S\_HLAT) and the longitude (S\_HLONG) which represent the location of the house in which the senior reside.

The drone (DRONE) entity has two attributes, which are the drone number (D\_ID) expressing the unique number assigned to one drone and the police station number (PO\_ID) to which the drone belongs.

The guardian (PROTECTOR) entity has four attributes, which consist of a protector number (P\_ID), a protector name (P\_NAME), a protector's cell phone number (P\_PNUM), and a senior number (S\_ID) that the protector wants to protect.

The police (POLICE) entity has five attributes, which consist of the unique number (PO\_ID) assigned to the police station, the police office number (PO\_PNUM), the name of the police station (PO\_NAME), and the latitude (PO\_LAT) and longitude (PO\_LONG) of the location of the police station.

Finally, a CAUTION entity indicates a hazardous area. The Hazard zone entity consists of three attributes, which are the hazard zones number (C\_ID), the location of the hazard zone latitude (C\_LAT), and the hazard zone longitude (C\_LONG).

### 3.2 Description of Schema and Relations

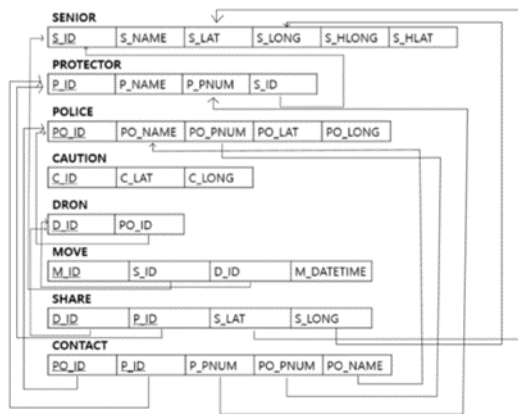


Fig 4: Database schema

The database schema configured based on the E-R diagram of Figure 3 is shown in Figure 4. The primary key of each table is underlined; the foreign key points to the attributes of the table to which the arrow points; the starting point of the arrow is the property of the table to which the foreign key belongs.

There are S\_ID, S\_NAME, S\_LOG, S\_LAT, S\_HLONG, S\_HLAT attributes in the SENIOR table, and the primary key of SENIOR is the senior number (S\_ID).

The PROTECTOR table has P\_ID, P\_NAME, P\_PNUM, S\_ID attributes and the primary key is P\_ID. In addition, the senior number (S\_ID) is foreign key, referring to the S\_ID attribute on the SENIOR table.

The POLICE table contains the attributes PO\_ID, PO\_PNUM, PO\_NAME, PO\_LAT, PO\_LONG and the primary key is the police station number (PO\_ID).

The CAUTION table has C\_ID, C\_LAT, C\_LONG attributes and the primary key is dangerous area Number (C\_ID).

The DRONE table has D\_ID, PO\_ID attributes and the primary key is D\_ID. In addition, the police station number (PO\_ID) to which the drone belongs

was used as foreign key referring to the police station number (PO\_ID) on the police table.

Out of the four relationships in the E-R diagram, three (MOVE, SHARE, CONTACT) were expressed as a schema.

The MOVE relation has a moving number (M\_ID) attribute; every time a drone is sent to a senior, it gives the movement of another drone and a new number that can be identified. In addition, there are S\_ID and D\_ID attributes that are moving along with the senior. And it consists of a date time attribute (M\_DATAETIME) that indicates the date and time when the movement occurred. The primary key of the MOVE relation is M\_ID, and the senior number and the drone number are entered as foreign keys.

The SHARE relation expresses the situation sharing to the protector and shows the real-time latitude (S\_LAT), real-time longitude (S\_LONG) of the senior. All these attributes are foreign keys, which are organized by reference to the attributes of other tables. Refer to the D\_ID of the drone table, the P\_PNUM of the protector table, and the S\_LAT, S\_LONG property of the senior table, respectively. The primary key consists of Drone Number (D\_ID) and Protector Number (P\_ID).

The CONTACT relation expresses the contact between the protector and the police station. It consists of the attributes of the police station number (PO\_ID), protector number (P\_ID), protector's phone number (P\_PNUM), police station office number (PO\_PNUM), and police station name (PO\_NAME). The CONTACT relation, as well as the SHARE relation, consists of all foreign keys. Refer to PO\_ID, PO\_PNUM, PO\_NAME on the POLICE table and P\_ID, P\_PNUM on the PROTECTOR table respectively.

The relational tables do not save the data separately because they can implement the results in SQL syntax when they produce useful results for the research. The results of each SQL statement will be stored on each relational table when it is linked to the app in the future.

## 4. REPRESENTATIVES OF USEFUL INFORMATION

The main services provided by the drone service database system are as follows:

First, it automatically sends a notification to the protector when the dementia senior goes out. The

protector can see that the senior was out of the house by looking at the notice.

Second, it usually guides to a police station near its current location only if the protector wants to share the situation, and then the protector can ask the police station to move the drone.

Third, when the dementia senior enters within the hazard zone, an automatic notification is given to the protector and the police station, and drones are automatically moved from the police station close to the current location.

The useful information required to provide these services is as follows:

#### 4.1 Notification of the Dementia's Going Out

The tables used in this query are SENIOR and PROTECTOR tables. The fact that the dementia senior goes out means that the real-time location is different from that of his/her home. Therefore, the condition is set to be the case where the longitudes of the real-time position (S\_LONG) and the house (S\_HLONG) are different, and where the latitudes of the real-time position (S\_LAT) and the house (S\_HLAT) are different. The real-time location of the senior is the latitude and longitude values measured under the assumption that the senior is wearing a GPS bracelet.

If the dementia senior goes out, the name of senior (S\_NAME), the name of the protector (P\_NAME), and the protector's phone number (P\_PNUM) are printed without any duplication. Through this SQL statement, when a dementia senior is out the service can send an alert to his or her protector's cell phone.

The results of the above query are shown in Table 1.

**Table 1. Notification Results of the Dementia's Going Out**

S_NAME	P_NAME	P_Pnum
Park Yeongja	Park Jeonga	010-0768-1674
Park Jeongja	Park Hyeongseo	010-0100-9955
Park Sunjeong	Park Hyeonseong	010-0267-7723
Park Chunja	Park Jinho	010-0333-0447
Park Gyeongja	Park Jeonghwan	010-0062-2105

Park Okja	Park Hanseo	010-0298-7991
Park Myeongja	Park Mina	010-0845-2002
Park Hwaja	Lee Eunji	010-0232-0951
Park Yeongmi	Lee Jihyeon	010-0334-0592
Park Miyeong	Lee Seohyeon	010-0274-4344

#### 4.2 Notification of the Dementia's Entering the Hazard Zone

The tables used in this query are SENIOR, CAUTION, and PROTECTOR tables.

The hazard zone is set at 50 meters from the dangerous areas such as senior citizens' traffic accident-prone areas and the residential areas of sex offenders. Since a 50-meter differs by about 0.002 when converted to latitude and longitude, the condition is set to be between the real-time position of the senior and the hazard zone  $\pm 0.002$ .

If the conditions are met, the senior name (S\_NAME), the protector name (P\_NAME), and the protector phone number (P\_PNUM) can be printed to automatically notify to the protector that the senior has entered the hazard zone. The results of the above query are shown in Table 2.

**Table 2. Notification Results of the Dementia's Entering the Hazard Zone**

S_ID	S_Name	P_Name	P_Pnum
s002	Kim Sunjeong	Kim Suyeon	010-0042-7880
s003	Kim Chunbae	Lee Yeongsin	010-0414-0200
s005	Kim Migyeong	Kim Eunji	010-0750-1845
s011	Kim Hwaja	Kim Hyeonseong	010-0608-0587
s044	Lee Mijeong	Choi Hyeonseong	010-0317-9929
s045	Lee Miyeong	Choi Jinho	010-0647-4417
s078	BaekSunja	Song Yeonsu	010-5400-9159
s079	BaekJeongsu	Song Eunseo	010-4189-8004
s096	Na Okja	Song Hanseon	010-4646-1831

### 4.3 Nearby Police Stations Closest to the Real-Time Location of the Dementia

<SQL execute statement>

```
SELECT DISTINCT TOP 5 PO_NAME,
PO_PNUM, ROUND (SQRT((s.S_LONG-
p.PO_LONG)*(s.S_LONG-
p.PO_LONG)+(s.S_LAT-
p.PO_LAT)*(s.S_LAT-p.PO_LAT)), 7) as
'DISTANCE'
```

FROM POLICE p, SENIOR s

WHERE S\_ID='s080' ORDER BY 'DISTANCE'
ASC;

The tables used in this query are POLICE and SENIOR tables.

For drones to reach the senior quickly, drones from the police station close to the senior's real-time location must be called in. Therefore, information is needed about the police station closest to the senior's real-time position.

Under these conditions, the location of one particular senior is required, so the location distance between the senior and the police station is randomly designated as an senior with a S\_ID of s080 and the distance between the location of the senior and that of the police station is arranged in an ascending order so that they can be identified in the order of the distance. The S\_ID will be implemented later by receiving the S\_ID of each senior.

The SELECT statement identifies the distance between the location of the senior and that of the police station. It has been created using a distance formula between two points.

$$\overline{AB} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

From the real-time longitude (S\_LONG) of the senior  $x_2$ , the longitude (PO\_LONG) of the police station  $x_1$  was subtracted and squared. From the real-time latitude (S\_LAT) of the senior  $y_2$ , the latitude (PO\_LAT) of the police station  $y_1$  was subtracted and then equally squared. The actual distance difference can be obtained by rooting the two values through the SQRT() function. TOP 5 prints out the five police stations with the least difference. The reason for printing out five police stations is to contact the nearest police station first, and then, if all the drones

from that station have been sent out, the next one from the nearest police station.

Through the query, the police station close to the location of the senior can be identified, quickly and in an orderly manner, and a protector can be directed to a nearby police station so that the protector can mobilize the drones.

**Table 3. Results of the Nearby Police Stations to the Dementia**

PO_NAME	PO_PNUM	DISTANCE
Hwa Gok3 police substation	02-2604-2133	0.0003282
Kkachisan Patrol Division	02-2604-5053	0.0183328
Ga Yang Patrol Division	02-3665-9112	0.021086
Yeom Chang Patrol Division	02-3665-0660	0.0331398
Gae Hwa Community Security Center	02-2661-0336	0.0498018

The results of the above query are shown in Table 3.

### 4.4 Drones in the Police Station of Automatic Move for the Dangerous Dementia

<SQL execute statement>

```
SELECT DISTINCT s.S_ID, s.S_NAME,
d.D_ID, p.PO_NAME, ROUND
(SQRT((s.S_LONG-p.PO_LONG)*(s.S_LONG-
p.PO_LONG)+(s.S_LAT-
p.PO_LAT)*(s.S_LAT-p.PO_LAT)), 7) as
'DISTANCE'
```

FROM SENIOR s, CAUTION c, POLICE p,
DRONE d

WHERE s.S\_LONG BETWEEN(c.C\_LONG)-
0.002 and (c.C\_LONG)+0.002 and s.S\_LAT
BETWEEN(c.C\_LAT)-0.002 and
(c.C\_LAT)+0.002 and d.PO\_ID=p.PO\_ID
ORDER BY 'DISTANCE' ASC;

The tables used in this query are the SENIOR, CAUTION, POLICE, and DRONE tables.

Not only the protector is notified when the dementia senior enter a hazard zone, but a drone should

automatically move to him/her. Therefore, the conditions set the same hazard zone as in 3.2, and list all drones belonging to the police station in the order of distance difference from the hazard. It is assumed that each police station contains five drones. When the service is developed in the future, it can output only drones that can be mobilized.

The results of the above query are shown in Table 4.

**Table 4. Results of the Drones for the Dangerous Dementia**

S_I D	S_NAME	D_I D	PO_NAM E	DISTANC E
s079	BaekJeong su	d06	Hwa Gok3 police substation	0.0005614
s079	BaekJeong su	d07	Hwa Gok3 police substation	0.0005614
s079	BaekJeong su	d08	Hwa Gok3 police substation	0.0005614
s079	BaekJeong su	d09	Hwa Gok3 police substation	0.0005614
s079	BaekJeong su	d10	Hwa Gok3 police substation	0.0005614
s078	BaekSunja	d06	Hwa Gok3 police substation	0.000749
s078	BaekSunja	d07	Hwa Gok3 police substation	0.000749
s078	BaekSunja	d08	Hwa Gok3 police substation	0.000749
s078	BaekSunja	d09	Hwa Gok3 police substation	0.000749
s078	BaekSunja	d10	Hwa Gok3 police substation	0.000749
s096	Na Okja	d06	Hwa Gok3	0.0015474

			police substation	
s096	Na Okja	d07	Hwa Gok3 police substation	0.0015474

## 5. CONCLUSIONS

### 5.1 Overall Conclusion

The paper proposes the drone functional safe welfare service system for the dementia seniors and their protectors utilizing drones and big data in Korea, which has entered an aged society at a rapid pace. To solve the problems of dementia seniors being exposed to danger and protectors with increased stress, it recommends that devices identify the real-time location of the dementia senior and the protectors and that the police station provide services that enable the drone to be dispatched and situation-sharing if desired.

Data from the dementia seniors and their protectors, the location-based and camera performance of drones, situation-sharing and police-station are key elements for safe services, which is an important foundation for providing out services in conjunction with the application.

The secure service for the dementia seniors focuses on the ability to prevent the seniors from being at risk and the provision of services tailored to their protectors needs.

By utilizing drones in the appearance of new innovative services and devices, we can live in a safer and more convenient life. Drone experts predict that drones will be used in many areas, including personal products, within 10 years. Futurologist Thomas Frey predicts drones as one of the seven emerging industries [19].

According to a survey by the Korean Society for Dementia, protectors for the dementia seniors feel pressured by the decrease in social life caused by nursing care, which leads to a surge in stress. This research has been initiated to increase the utility value of drones by providing safe out-of-the-box services for dementia seniors, to reduce the stress of their protector, and to stabilize the civil service at the police station. Based on the statistics of police stations and the data of senior citizens in Seoul Metropolitan Area, it automatically analyzes the

possibility of drones appearing when the senior is out and comes within the danger zone radius.

## 5.2 Contributions

The expected contributions by implementing the research are as follows.

First, the service system will contribute to reducing the missing probability of a dementia senior when they are going out without protection from their protectors.

Second, the service system can reduce the stress of protectors of dementia seniors. Currently, the dementia senior is usually cared by a protector who is a member of the family claiming to be a protector or by hiring a protector. When real family members start nursing, the protector stress increases due to a decrease in social lifetime. Conversely, even if protectors are employed or dementia seniors are hospitalized in nursing homes, the same result is achieved by an increase in the economic burden. However, by introducing drones, protectors will be able to identify the real-time location of dementia seniors, enabling them to focus on their social work and leisure.

Third, to protect various social underdogs beyond dementia seniors, it can increase the performance efficiency of the police administration.

In the past four years of Korea, a total of 458,369 people has been reported missing from their homes with dementia, children, intellectual disabilities and adult runaways. Also, 4,654 people have been reported missing but have yet to be found, with 116 cases for the intellectually disabled and 24 cases for the dementia seniors. The social underdogs are often shivering with cold, fear and strange moods when they go missing. Introducing a system to watch whether these socially disadvantaged people return home safely while going out freely will not suppress their freedom of going out and allow them to recognize any mishaps in advance, making it easier to deal with.

Fourth, by a national institution, in 17 years Korea will become an aged society with more than 14 percent of the population aged 65 or older [20]. This suggests that the nation is on the verge of entering a super-aged society at a rapid pace, meaning that the nation should prepare a robust welfare security system for the senior from now on. According to a survey on dementia epidemiology, one out of 10

seniors in 2018 are dementia seniors, and by 2050, one out of six seniors could become dementia seniors. Through the actual introduction of the "Dementia senior patrol sensor" the number of missing persons reports has decreased from 225 in 2015 to 187 in 2017 [21].

Fifth, if the service is stable it may expand the scope of the target and provide safety services to socially disadvantaged people such as children, the seniors and the disabled, which will increase the overall effectiveness of the safety of the Republic of Korea.

If the system provides real-time sharing of the situation using drones, it will further reduce reports of missing persons and increase the credibility of the national flag organs.

## 5.3 Limitations

Limitations of the research are as follows.

First, the technical limitations of the drones should be complemented. For commercial purposes, the flight time is only 15 to 20 minutes, and for commercial products, the flight distance is about 50 kilometers. Advance in battery technology that can fly for longer periods of time is essential. Also, the technology to prepare for a crash caused by a collision between drones and faulty gases should be complemented.

Second, government-level regulations are a challenge to overcome. Not only do they look at drones from country to country, but they also have different regulations and systems. In the case of Korea, five laws are regulated: The Aviation Act, the Propaganda Act and the Road Act. In line with the era of the fourth industrial revolution, drop-related regulations and systems should also be improved and supplemented to suit the times. In order to use drones in the private sector, the current aviation law or the radio wave law needs to be revised.

## 6. ACKNOWLEDGEMENTS

This work was supported by Hankuk University of Foreign Studies Research Fund of 2019.

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