
# Research Article

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# Location-Based AI-Assisted Filiation Software for Isolation of Epidemic Diseases

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**Abstract:** Filiation is a technique used to find the first source of the disease in epidemics. As a result of filiation studies, basic and very important information such as the causes of the disease and transmission routes can be obtained. Health units can take preventive measures or plan some health services with the data they have obtained as a result of these studies.

The purpose of this study is to follow the spatial movements of people with smartphones in daily life and to isolate the person in case of possible pandemic danger. In this context, it is aimed to determine the locations of infected people in coronavirus and other epidemic diseases, to map the filiation, and to help ensure social isolation. In this context, a tracking software that works on Android and IOS systems with flutter technology has been developed to retrieve user locations. The tracking software transfers the user location information to the central server. When there is a temporal deficiency or possible Global Positioning System (GPS) differences in the received location information, the missing data in the server is estimated by the developed Long- Short Term Memory (LSTM) deep learning model. The model can make accurate predictions over 99%. In the last step of the study, the main tracking and mapping software was developed with C#. In an inquiry made with a positive patient's phone number, positional matches are extracted at the same time as the person. In this way, filiation scanning is performed on the map. As a result, with the widespread use of the study, it is aimed to take faster and more accurate measures to prevent the epidemic from infecting more people. In this context, it is aimed to determine the locations of infected people in coronavirus and other epidemic diseases, to map the filiation, and to help ensure social isolation.

**Keywords:** Filiation, Location-Based Service, LSTM, Epidemic

## 1.INTRODUCTION

The world has been shaken by the COVID-19 pandemic, one of the biggest epidemics of the last century. This pandemic has spread at an unprecedented rate in history and has caused many people to die globally. The crisis created by the pandemic has caused serious difficulties in many sectors, and many institutions around the world, including businesses, educational institutions and health services, have had to turn to digitalization. Since the epidemic limited people's gathering, businesses and institutions had to maintain their communication and services through digitalization[1].

Controlling epidemics is a very important point for public health. Many different approaches are used to control outbreaks. These include basic measures such as following the social distance rules, wearing masks, and paying attention to hand hygiene. In addition, the use of technological tools has gained importance in controlling epidemics. At this point, mobile applications have come to the fore among the technological tools used in pandemic control [2-3].

One of the reasons why mobile applications have become an important tool in the fight against the COVID-19 epidemic is that users always carry their smartphones with them and these applications are easy to use. In addition, the development and use of mobile applications help to eliminate the lack of information on public health by reducing the uncertainties experienced during the pandemic process. One of the other reasons why mobile applications can be used as an effective tool in the control of epidemic diseases such as COVID-19 is that these applications can be very effective in areas such as the detection of infected people, the follow-up of contacts, and the sharing of public health information. However, there are various concerns about the effectiveness of mobile applications, the voluntary use of these applications by users, and the security of their data. In order to eliminate these concerns, measures should be taken, such as adequately informing users about the privacy and security of their information, and clearly stating standards in the development of applications [4-5].

Many of these mobile applications work with location information from the mobile device. With the GPS sensor in smart devices, the user's location information can be easily collected [6]. Location-based services (LBS) can monitor events such as traffic density and spatial crowding on maps with this information collected. At the same time, in cases where there is heavy user traffic, mobile applications can make suggestions to users (arrival time, best route, most preferred location, etc.) [7]. Location-based services, which have been of great importance since they were opened for civilian use, are frequently used to track and detect where people are. With the developed applications, families can easily track the location of their children during the day [8].

First of all, the source of motivation for the study can be explained as follows. It is seen that Turkey is the country that makes the most common filiation work during the fight against COVID-19 in the world. In our country, filiation is done as follows [9].

- When there is a diagnosis diagnosed with COVID-19, work and family information is automatically dropped into the system.
- Important information is obtained from this patient, such as family information, who he has been in contact with recently, and where he has been.
- The filiation team consisting of 3 people starts the scanning process within 48 hours at the latest.

This study, it is aimed that the process applied in the 2nd step is done automatically by the software. This process is the part where the filiation teams spend the most time and labor. Thus, a significant time and workload advantage will be provided. At the same time, we can list the innovations and contributions of the study as follows.

- Creation of a location-based big data model.
- Person and time-based filiation mapping.
- Notification of the location matches the potential suspect in the same time frame as the infected person.
- Protection of people's spatial information against possible attacks with location privacy protection mechanisms.

The proposed study monitors the spatial movements of people with smartphones in daily life, ensuring that the person is isolated in the danger of a possible pandemic. In coronavirus and other epidemic diseases, it is aimed to determine the locations of infected people, to map the filiation, and to help ensure social isolation. In addition to providing personal protection, in the coronavirus epidemic, the contact map of the infected people will be automatically drawn, and informing of the people who have come into contact or shared the same environment will make greater isolation possible. In addition, the filiation map will enable health institutions to take faster and more accurate measures against the epidemic.

## 2. DEVELOPMENT OF FILATION AND MONITORING SOFTWARE

### 2.1. Preparation of the Database

In this section, two different database models are developed. The first is the MS-SQL Server 2019 relational database, which is used for storing and processing all information on the artificial intelligence server (Figure 1). Since the database designed on the Microsoft Management Studio platform will store large data, optimization and performance techniques have been applied during its development. The basic configuration procedures for this are summarized as follows.

- Shared connection support is disabled because it will be accessed via TCP connection.
- The FILEGROWTH feature of the database is set to 1GB.
- AWE feature enabled to use more than 4GB of RAM.

Secondly, SQLite database is used to store location information in mobile applications when there is no internet connection (Figure 2). SQLite is automatically created in the directory where the application is installed in mobile applications. This database only stores temporary data when there is no internet.

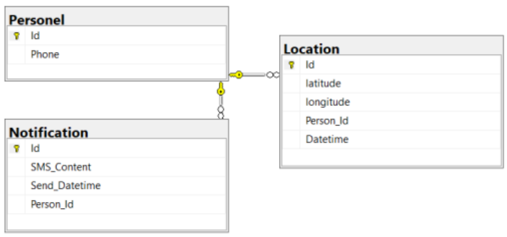


**Figure 1.** Diagram structure of SQL SERVER database

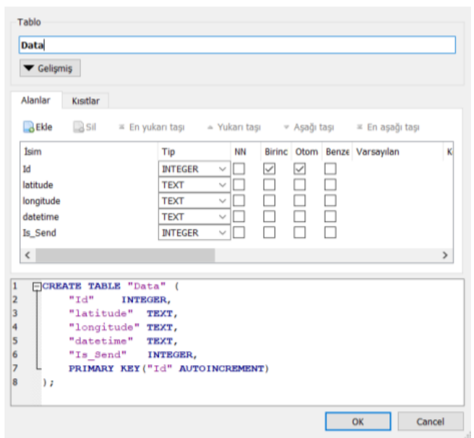


**Figure 2.** Diagram structure of SQLite database

### 2.2. Coding Web Services

REST (Representational State Transfer) was used to transfer the data in the mobile application to the SQL server database on the server. Communication is provided between the mobile client and the server. Transactions made in the developed REST architecture were done with the concept of a resource. These resources are identified by the Uniform Resource Identifier (URI). REST services also make requests directly with HTTP methods with URIs, there is no need for a Web Services Description Language (WDSL) like SOAP. In this way, CRUD (Create, Read, Update, Delete) operations were performed on the database. For this, the following HTTP methods are used in REST.

- GET > Select
- POST > Insert
- PUT >Update
- DELETE > Delete

**For login;**

```
POST /api/2/auth/signin HTTP/1.1
HOST: ms-server
Content-Type:text/xml
<tsRequest>
  <credentials name="user" password="xxxx">
    <site contentUrl="" />
  </credentials>
</tsRequest>
```

**To send a new data:**

```
POST /api/2.2/sites/9a8b7c6d-5e4f-3a2b-1c0d-9e8f7a6b5c4d/users HTTP/1.1
HOST: ms-server
X-Tableau-Auth: 12ab34cdsdserv45f4g66cd
Content-Type: application/json
{
  "data": {
    "latitude": "xxx",
    "longitude":  "xxx",
    "Phone":  "xxx",
    "Datetime":  "xxx"
  }
}
```

Microsoft SQL Server Hevo Data was used to load data from REST API to Microsoft SQL Server. With this method, a data flow task is created by establishing a REST-based connection. Then the "DataModel" property is used to map the incoming data and load the data correctly into your Microsoft SQL Server database. The data from the REST API has been transferred to the database on the server without writing any code.

### 2.3. Development of Mobile Applications

The mobile application runs on Android and IOS operating systems, which constitute a high proportion of smart mobile devices. For this, Flutter technology is used on Android Studio [9]. As seen in Figure 3, the mobile application asks the user for name, surname, and phone information at first startup. In order to specify the purpose for which this personal data will be used and to obtain approval, approval will be requested with a previously prepared clarification text. After the user approves the application, this screen does not appear again.

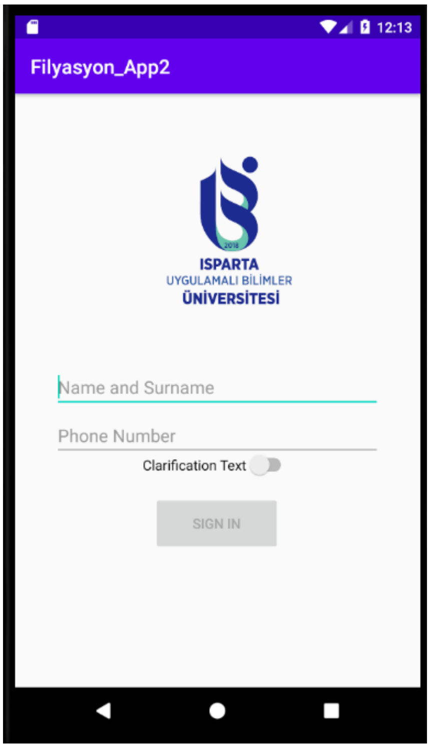


**Figure 3.** Mobile Application splash screen

The timer in the application works every 1 minute. Every time it runs, it first checks the internet connection. The following code snippet has been developed to control the internet connection with flutter.

```
import 'package:connectivity/connectivity.dart';

var connectivityResult = await (Connectivity().checkConnectivity());
if (connectivityResult == ConnectivityResult.mobile) {
  // there is mobile internet
} else if (connectivityResult == ConnectivityResult.wifi) {
  // there is WIFI
}
 else
//  there is no internet
```

The following permission request structure and data flow codes are used to obtain user location information.

```
import 'package:location_permissions/location_permissions.dart';
PermissionStatus permission = await LocationPermissions().requestPermissions();

class LocationData {
  final double latitude;
  final double longitude;
  final double accuracy;
  final double altitude;
  final double speed;
  final double speedAccuracy;
```

```
  final double heading;
  final double time
}
```

If there is no internet connection in the application, import android.database.sqlite.SQLiteDatabase and import android.database.sqlite.SQLiteOpenHelper libraries are used to keep the data in the SQLite database.

### 2.4. Development of Artificial Intelligence Decision Support System

In the study, the artificial intelligence model will be used to estimate the user's location in cases where the positions taken from the GPS are missing, incorrect or the positional distance is excessive. In the preliminary and writing part of the study, it is planned to use a machine learning algorithm due to the possibility of insufficient data set. However, due to the high number of data in the current situation, the Long Sort Term Memory (LSTM) algorithm, which gives successful results in time series predictions from deep learning algorithms, has been preferred [11-12].

In the first stage, the data collection process was applied for the training and testing of the artificial intelligence-based decision support system model. The developed mobile application was installed on 5 different users and spatial data was collected every 5 minutes. Over 1 million location data were collected during the 120-day data collection period. 80% of the collected data is divided into training and 20% as testing.

The normalization process is applied to the raw data, providing the final shape of the dataset required for training. Techniques such as Min-Max, Median, Sigmoid, and Z-Score are used to normalize. The most widely used of these techniques is the min-max normalization (Equation 1). Therefore, the data were optimized using the minmaxscaler normalization scale in the preprocessing process of the dataset [13].

$$z = \frac{x - \min(x)}{max(x) - \min(x)} \tag{1}$$

In the training of the model, the weight matrices were started with values close to zero. The learning rate was initially α = 0.01, and the training round value was updated to α = 0.001 after 10. The necessary hyperparameters for training the model were determined as shown in Table 1.

**Table 1.** Hyper and standard parameters of the model

| Hyper parameter and other parameters | Value |
|---|---|
| train data | 800.000 (80%) |
| test data | 200.000 (20%) |
| input | 2 |
| Batch size | 128 |
| epoch | 75 |
| learning rate | 0.001 |
| dropout | 0.4 |
| layer | 2 |
| output | 1 |

To evaluate the error performance of the developed LSTM model, k Mean Squared Error (MSE) was preferred. The development codes of the 2-layer model are as follows.

```
model = Sequential()
model.add(LSTM(64,batch_input_shape=(None,timestep,1),return_sequences=True))
model.add(Dropout(0.2))
model.add(LSTM(32,return_sequences=False))
model.add(Dropout(0.2))
model.add(Dense(1))

model.compile(loss='mse',optimizer='rmsprop')
model.fit(Xtrain, Ytrain, batch_size=512, epochs=100)
```

The training and testing process of the developed model has been completed on the Ubuntu operating system with Intel I9 3.9 GHZ processor, 64 GB RAM, and NVIDIA 2060TI graphics card. The estimation engine is independent of the main software, and in case of missing data, it is used manually to complete the spatial deficiencies. Therefore, it is not integrated into the main software.

To test the accuracy of the proposed model, it is compared with traditional machine learning algorithms on the same dataset. In this comparison, the LSTM model and Support Vector Machine (SVM), K-nearest Neighbors (KNN), multilayer neural network (MLP), the linear classifier with stochastic gradient descent (SGD), gradient boosting (GB), and Back-Propagation Neural Networks (BPNN) used. For location detection in all algorithms, the model was trained on the same dataset and a classifier was created. In Table 2, accuracy and MSE results are given in terms of the estimation accuracy of the test data. Accordingly, the proposed LSTM model leaves traditional machine learning algorithms behind. The strong learning ability of LSTM has been shown to be correct to use as a prediction in real-world applications.

**Table 2.** The results of the LSTM model and its comparison with other methods

| Model | Accuracy | MSE |
|---|---|---|
| LSTM Model | 0.9972 | 0.0002 |
| SVM | 0.9745 | 0.0021 |
| KNN | 0.9705 | 0.0026 |
| MLP | 0.9542 | 0.0032 |
| SGD | 0.9410 | 0.0034 |
| GB | 0.9484 | 0.0043 |
| BPNN | 0.9380 | 0.0052 |

### 2.5. Mapping and Monitoring Main Software Development

The main software will be used to detect the contacts of that person when the COVID-19 test of a potential person is positive as a result of hospital tests. In this part of the study, the main monitoring and mapping software was developed as shown in Figure 4. This software can call users in the MSSQL database via phone number. As a result of the search, the last 1-day location movements are positioned with Google Maps APIs as a test. People who are in the same location as the person detected in the same time period are shown in the list box on the right. In addition, data examples used in query and matching are shown in Figure 5.

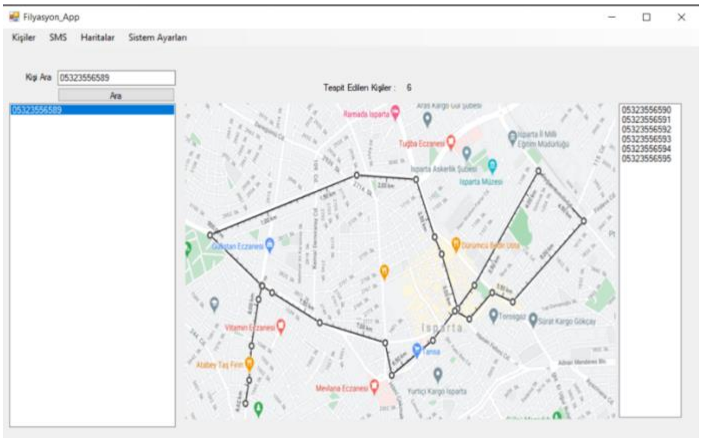


Figure 4. Sample test image from the main software

| id | phone | name | latitude | longitude | createdAt | updatedAt |
|---|---|---|---|---|---|---|
| 151 | 5320521007 | O?uzhan Bulut | 39.8256303 | 34.8125506 | 2021-05-02 15:03:55 | 2021-05-02 15:03:55 |
| 152 | 5320521007 | O?uzhan Bulut | 39.8256302 | 34.8125507 | 2021-05-02 15:03:57 | 2021-05-02 15:03:57 |
| 153 | 5320521007 | O?uzhan Bulut | 39.8256302 | 34.8125507 | 2021-05-02 15:03:59 | 2021-05-02 15:03:59 |
| 154 | 5320521007 | O?uzhan Bulut | 39.8256302 | 34.8125507 | 2021-05-02 15:04:00 | 2021-05-02 15:04:00 |
| 155 | 5320521007 | O?uzhan Bulut | 39.8256302 | 34.8125507 | 2021-05-02 15:04:02 | 2021-05-02 15:04:02 |
| 156 | 5320521007 | Oguzhan | 39.8256302 | 34.8125507 | 2021-05-02 15:05:15 | 2021-05-02 15:05:15 |
| 157 | 5320521007 | Oguzhan | 39.8256293 | 34.8125502 | 2021-05-02 15:06:20 | 2021-05-02 15:06:20 |
| 158 | 5320521007 | Oguzhan | 39.8256283 | 34.8125507 | 2021-05-02 15:07:26 | 2021-05-02 15:07:26 |
| 159 | 5323556590 | Aas | 37.7605581 | 30.5421967 | 2021-05-02 15:19:06 | 2021-05-02 15:19:06 |
| 160 | 5323556590 | Aas | 37.7608129 | 30.542089 | 2021-05-02 15:19:46 | 2021-05-02 15:19:46 |
| 161 | 5323556590 | Aas | 37.7607262 | 30.541959 | 2021-05-02 15:21:15 | 2021-05-02 15:21:15 |
| 162 | 5323556590 | Aas | 37.7604064 | 30.5421438 | 2021-05-02 15:21:52 | 2021-05-02 15:21:52 |
| 163 | 5323556590 | Aas | 37.7603866 | 30.5421568 | 2021-05-02 15:22:54 | 2021-05-02 15:22:54 |
| 164 | 5323556590 | Aas | 37.7606687 | 30.5422311 | 2021-05-02 15:23:59 | 2021-05-02 15:23:59 |
| 165 | 5323556590 | Aas | 37.7607541 | 30.5420034 | 2021-05-02 15:25:03 | 2021-05-02 15:25:03 |
| 166 | 5323556590 | Aas | 37.7605539 | 30.5422163 | 2021-05-02 15:26:11 | 2021-05-02 15:26:11 |
| 167 | 5323556590 | Aas | 37.7604103 | 30.5420634 | 2021-05-02 15:27:12 | 2021-05-02 15:27:12 |
| 168 | 5323556590 | Aas | 37.7606565 | 30.5421984 | 2021-05-02 15:28:15 | 2021-05-02 15:28:15 |
| 169 | 5323556590 | Aas | 37.7606596 | 30.5422269 | 2021-05-02 15:29:21 | 2021-05-02 15:29:21 |
| 170 | 5323556590 | Aas | 37.7607025 | 30.5422965 | 2021-05-02 15:30:32 | 2021-05-02 15:30:32 |
| 171 | 5323556590 | Aas | 37.760388 | 30.5420578 | 2021-05-02 15:32:11 | 2021-05-02 15:32:11 |
| 172 | 5323556590 | Aas | 37.7604705 | 30.5421931 | 2021-05-02 15:36:47 | 2021-05-02 15:36:47 |
| 173 | 5323556590 | Aas | 37.760311 | 30.5421275 | 2021-05-02 15:37:43 | 2021-05-02 15:37:43 |
| 174 | 5323556590 | Aas | 37.7606011 | 30.5421458 | 2021-05-02 15:38:46 | 2021-05-02 15:38:46 |
| 175 | 5323556590 | Aas | 37.7602581 | 30.5420455 | 2021-05-02 15:39:48 | 2021-05-02 15:39:48 |

**Figure 5.** Sample image from the records coming to the server

## 3. CONCLUSION

Filiation is a study to find the first source of the disease in epidemics. As a result of filiation studies, basic and very important information such as the causes of the disease and transmission routes can be obtained. Health units can take preventive measures or plan some health services with the data they have obtained as a result of these studies. Countries (Turkey, Australia, China, South Korea, India, and Germany) are developing their own practices during this epidemic period. These applications instantly warn the person against the infected person via Bluetooth. Although it provides instant positional protection of the person, it does not provide a filiation mapping that can be used by health institutions.

The proposed study is aimed to monitor COVID-19 and other epidemic diseases that may be seen in Turkey and the world in the future and to take the necessary precautions. In addition to providing personal protection, wider isolation is achieved by informing the people who have come into contact with or shared the same environment by drawing the contact map of the infected people in the social corona virus epidemic. In addition, the study allows health institutions to quickly draw maps of the individual's filiation. During pandemic periods, the significant reduction of both time and workload for health personnel aims to play an important role in bringing the epidemic under control faster.

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