Design and Implementation of GPS Trajectory Location System Based on Android

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Abstract. In order to meet the diverse needs of geographic location scenarios, a diversified location-based smart phone APP is designed and implemented. The app is based on the Android platform, using the Baidu Map API as a tool to achieve real time monitoring through the active push of geographic information.It can basically meet the needs of geographical location sharing and monitoring in life and work. Aiming at the deviation of Baidu map network positioning and GPS positioning, the optimization will also be proposed.

Introduction

With the development of science and technology, mobile terminal technology has been inseparable with our lives. The number of various application development software based on Android has shown a rapid growth in recent years. For example, mobile search, mobile positioning, mobile phone monitoring, streaming media applications and many data services have been widely used[1]. And the positioning based on Android technology has a very broad application range. By sharing geographical information, we can achieve multiple positioning and trajectory tracking, allows users to care about people who need to be concerned.It provides effective solutions to the company geographical monitoring, scheduling management, family care, etc.

System Architecture Design

Android Platform. Android is a Linux-based open source mobile operating system. Google launched and published the initial development in 2007. The system adopts a layered architecture includes Linux Kernel, Android Run time, Application Framework and Application. The Android platform has good openness and compatibility too.

Location Mode

Base Station Location. Communication signal is sent by a base station in a plurality of known locations which has base station location information. When the mobile terminal receive these signals, it can determine the geometric position relationship. Then, the location of oneself is estimated based on some specific related algorithms. And the terminal can get the position information.

Network Location. This positioning technology receives the target communication signal through the fixed communication base station,and determines the accuracy of the information.Besides,it requires the positioning mobile terminals to issue some special communication signals.

GPS Location. The GPS (Global Positioning System) is a radio navigation positioning system established by the United States Department of Defense to meet its military navigation and positioning. The GPS system uses the instantaneous position of the satellite in high speed motion as the original data, and then to determine the longitude and latitude coordinates of the position by the method of spatial distance intersection.

The system uses Baidu Map API to achieve positioning. It will choose the appropriate way to locate based on the availability of GPS, the network situation and other practical conditions.

System Architecture. Fig. 1 shows the basic schematic diagram of location sharing framework. The implementation steps for a location push are as follows:

a. The client collect and process data by calling the Baidu Map Location API . These data can improve accuracy by filtering large precision points and raising the positioning frequency.
b. The client uses volley network framework to send information to the server. Volley is very suitable for the high frequency network request of small data volume[3]. And it meets the high frequency of GPS data transmission scenarios.
c. The server stores data into the database and actively pushes the information to another client via Message Push. Message push is a long connection active behavior based on TCP[4].
d. The client receives and parses the JSON format data through the BroadcastReceiver and draws it onto the map overlay.
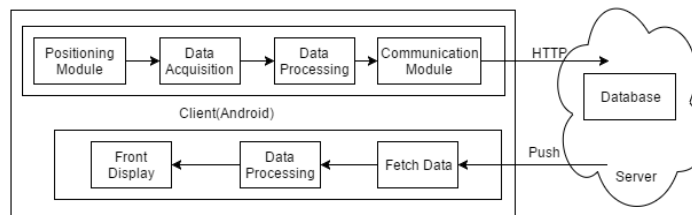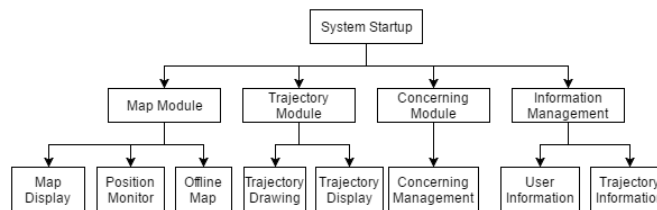

Fig. 1. System architecture diagram

Fig. 2. System function diagram

When a user logs on system, search and add some other users, the user is the observer and the other is the observed. When the observed begins recording position, the system posts the location information to the server, and the server push the information to the observer. The "post-push" process can define a relationship modeled by "one-to-many".And this system can capture the change on the mobile phone in 5 seconds, basically meet the real-time monitoring requirements.

Considering that monitoring may be mutual, the system authorize user to be the observer and the observed. which can greatly meet the various location monitoring scenes in work and life.

System Function Design

As shown in Fig. 2, the system can be divided into four different modules. In the map control module, the map view can be moved, rotated, zoomed and so on. Users can monitor the location of others and use offline maps. In the track management module, the system can draw the user's moving trajectory on the map and show to user directly. In the information management module, the user can check the details of the previous track record, and can check and edit personal information.

Map Module. It's need to apply for Baidu Map API key, download SDK and integrated into the project. Then place the Map View control into the layout file and initialize the map in the Activity. By controlling the mBaidumap, the display mode of the map, zoom ratio, cover, positioning display and other functions can be achieved. The core code shown as follows:.

```
mBaiduMap = mMapView.getMap();
MapStatusUpdate msu = MapStatusUpdateFactory.zoomTo(18.0f);
mBaiduMap.setMapStatus(msu);
 mBaiduMap.setMapType(BaiduMap.MAP_TYPE_SATELLITE);//set satellites map
MyLocationData data = new MyLocationData.Builder()
       .accuracy(location.getRadius())
       .latitude(location.getLatitude())
       .longitude(location.getLongitude())
       .build();
mBaiduMap.setMyLocationData(data);// set position
```

When start to record the location, the observer client uses the BroadcastReceiver to achieve location information, and sends to the activity via the observable provided in Android. Users can view each others' track in real time when they press the track button in the Info Window. When the observed position is abnormal, users can click the phone button to call directly.

Trajectory Module. The module mainly realizes the real time drawing of the trajectory and the adaptive view of the historical trajectory. The real time rendering of trajectory uses the latitude and longitude points to draw lines directly on the map overlay. The code is shown as follows:

```
.nowlocal = local;  //local is the latitude and longitude point that is currently located

drawTrace();
lastlocal = nowlocal;
```

Due to the trajectory of the route is long and short, the map sets zoom ratio defaults to 50 meters. In order to display the track intuitively, the map can be scaled freely. The system use LatLngBounds to construct a builder object with all latitude and longitude points and implement the map-adaptive trajectory through MapStatusUpdateFactory.

Concerning Module. The system uses friends list which divided into "concern" list and "be concerned" list. List of "friends" have a user name and avatar, which is sort by alphabetical alphabet. As large amount of user list images loading may lead to OOM (Out Of Memory, memory leak) problems, so use DiskLruCache(disk cache) and LruCache(memory cache) to achieve image secondary cache. The principle is as follows:

a. Set the cache size of the LruCache, and release pictures cache which are not shown.
b. ImageLoader in the List adapter find pictures in memory according to the picture's URL, if exists, then loaded, otherwise turn c.
c. ImageLoader find pictures in disk according to the picture URL MD5 value, if exists,then loaded and stored in memory, otherwise turn d.
d.ImageLoader get pictures in the server by the URL, loaded and stored in memory, and disk.

Location and Accuracy Optimization

Background Service Location. Actually, the home screen will not always display when the positioning function is turned on. So, we need to record the location, save the data, and upload to the server by the way of background service. In order to remedy the startService and bindService disanvatages,they will work together. The realization process is as follows:

a. Create the Intent and ServiceConnection instances that start the service in the map Activity.
b. Initialize the targeting settings in the location service named LocationService.
c. Call startService(Intent i) and bindService(Intent i, ServiceConnection con, int flag) to start the service.
d. Obtain the service object from the binder instance in the onServiceConnected callback method.
e. In the LocationService,through the BDLocationListener to access the data of location and upload, deposited into the local database and callback to the Activity.
f. If Activity exists,call the service object's monitoring method then show the positioning or drawing trajectory on the map. If not, service is still positioning, and prepare for the next time.

Optimization of Positioning Accuracy. If GPS is turned on, the high-precision positioning of Baidu map will use the network positioning and GPS positioning to obtain high-precision positioning results.Otherwise, the device will use network positioning as a result,which only contains latitude and longitude that may lead a great deviation. The system provide some methods to solve this problem.When GPS is off, and signal is normal, the accuracy of network positioning has about 40m. Otherwise, the accuracy has more than 100m deviation and the anchor point may jump between 100m. It is unfriendly if draw trace by this way. So, the optimization method is provided as follows:

a. Increase the frequency of positioning. Such as,change every 5s to every 1s.
b. Filter large precision points. Screen out more accurate positioning point.
c. Filter the jump point. When the signal is bad, some points can be excluded.

However, when the signals stay bad for a long time, all of the points will be filtered and the drawing will be broken.If GPS is turned on, the positioning accuracy is 3m to 5m under the common signal.But,the location still may has a wide range of deviation. In this case, the system uses the Kalman Filter[5]to optimize the trajectory. The system calculates the optimal weight of latitude and longitude values based on the previous difference, and recalculate the current time variance.The results are shown in Fig. 3 and Fig. 4.
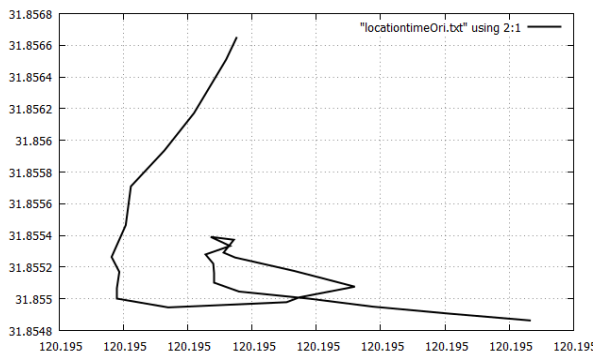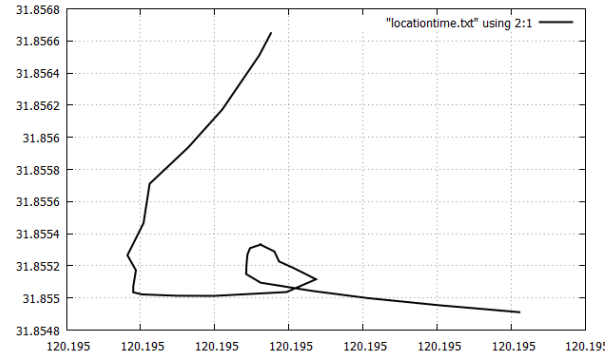

Fig. 3. Trajectory before optimization   Fig. 4. Optimized trajectory

As can be seen, the results are very different when the accuracy of GPS is high or not.So we can draw a conclusion,the filtered trajectory is smoother and friendly to the user and optimization effect .

Summary

The system uses the Android development technology and Baidu Map API to develop a location based service (LBS) Android application. The application can achieve real-time location exchange, monitoring and walking route sharing. The application is simple-used, running smoothly, and user-friendly, so that people can record their own or pay attention to others walking routes. The system can be widely used in corporate management scheduling, children and elderly care, travel sharing and other fields. Bring convenience to people's life and work.

Acknowledgements

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