Indirect Geolocation Methods in mHealth Applications

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***Abstract*—The paper describes the different types of indirect geolocation methods and the peculiarities of their functioning in mHealth applications and services. The main discussed criteria include the accuracy of the methods, their fidelity, the simplicity of implementation and accessibility by mobile applications. A variant of implementing a geolocation service is described as an example.**

I. Introduction

It might be desirable to use the data about the location of the mobile device of user in certain scenarios of mobile applications and human health monitoring services. However, it is not always possible to determine the location exactly, using the data of satellite geolocation systems, such as GPS or GLONASS. It can be explained by the lack of necessary equipment (satellite receiver), deliberate deactivation of a satellite receiver by a user, too long search of the satellites, required for positioning or the inaccessibility of their signals. Therefore, one has nothing else to do, but to use indirect methods which do not use satellite systems data directly and have less positioning accuracy. Another reason for using indirect methods is the desire to save the mobile device battery. In this case primary positioning is performed by indirect methods, with satellite geolocation switched on when necessary. When we talk about the scenarios of using mHealth applications, the decrease of positioning accuracy to hundreds of meters or even several kilometers is not significant and does not reduce the consumer appeal of mHealth systems. Such scenarios include controlling the location of senior citizens suffering from acute sensory disorders, Alzheimer’s disease and similar health problems [1], or scenarios using contextual data, based on geolocation – for example, supervision over patients with hypertension [2] or cognitive behavioral therapy [3].

The result of the research was the development of the geolocation service for mHealth applications, based on indirect methods.

II. The Requirements to Indirect Geolocation for mHealth Applications

The following demands to indirect geolocation methods were developed on the basis of possible scenarios of using mHealth applications:

- Location accuracy – determined by the deviation radius of actual coordinates from the ones, provided by an application. In the applications with the location control the desired accuracy must not be less than several hundred meters. For the applications with contextual data the accuracy of several kilometers is allowed.
- Location accuracy probability – the probability of the obtained coordinates corresponding to the actual location. If the probability of a certain measurement is low, such positioning should be ignored.
- The possibility of the delayed determination of the location. – in mHealth applications scenarios it is impossible to provide constant Internet access during measurements, therefore there should be a possibility for geolocation methods to register primary indirect geolocation data without actually using the Internet with the following transformation of these data into actual location coordinates.

III. Geolocation Methods and Their Peculiarities

The main available indirect geolocation methods, used for mobile applications and devices, are as follow:

- The IP address for accessing the Internet [4];
- The data from cell towers [5];
- WiFi networks AP data [6].

The main problem of determining the location by IP address of the Internet connection in some cases the low accuracy of determining the location of the Internet connection by Internet providers from a certain city or region. This could be explained by the fact that a client’s IP address can be provided dynamically from the whole pool of the addresses registered by the provider which are in no way connected with the users location. The second problem of the method is the fact that it cannot be used for the delayed determination of location, which reduces its importance. But, despite all its drawbacks this method is available for all types of devices and applications, as it does not require any additional special equipment in addition to usual Internet connection.

Geolocation by cell towers data is based on the registration of the cell tower ID code (this tower should be within the visibility range of the device cellular radio module) and the signal strength of this tower. In order to increase the accuracy one can use the signals of nearby towers, if the mobile device cellular radio module can obtain this kind of information. This method has average positioning accuracy, gives the opportunity of delayed coordinates determination and is ideal for mHealth applications because it provides guaranteed positioning, ranging from several hundred meters in the city to 10-20 km. in the country, which is enough for contextual data scenarios, based on geolocation. The main problem of this method is that in the course of their operation cell towers and base transceiver stations can change their geographical position and this information is not updated regularly. One factor limiting the use of this method is that a mobile device should always have an active cellular radio module.

Geolocation on the basis of WiFi AP data is based on the identification of MAC addresses of access points within the operating range of the client's mobile device, the WiFi adapter and RSSI. This method has a better potential for greater positioning accuracy, compared to cell towers. It can be explained by the fact that the operating range of each AP is limited to 10-50 meters. The geolocation principle is quite similar to the example with cell towers above. It uses the database, which has the information about the AP MAC address and its actual location. The main drawback of this method lies in the fact that at present we do not have a comprehensive and accurate database of WiFi access points, and their structure has not stable yet. The advantage of this method is easy availability of facilities, required for its functioning – most mobile devices, such as phones and tablets are equipped with a WiFi adapter.

IV. The implementation of indirect geolocation service

The prototype of such service was created, based on the requirements to indirect geolocation methods within the context of mHealth applications and services. It should be pointed out that most of currently existing on the market mobile operation systems already have a geolocation function on the basis of indirect methods, however, it works only when the Internet connection is available, which contradicts one of the requirements to our service. The second drawback of this approach is that in most cases the parameter of the accuracy of finding the coordinates is unavailable for applications via API.

The developed service uses a number of external databases and services for comprehensive positioning.

In order to perform geolocation by IP address we use MaxMind database GeoIP [7]. If the addresses belong to the regions in Russia and Ukraine IpGeoBase's database [8] is used, because it has higher accuracy in these regions.

In order to perform geolocation by cell towers the positioning is done using the data from OpenCellID project [9], kept on the server, as well as several external services of Google (Google Maps Geolocation API), Yandex (Yandex.Locator) and Mozilla (Mozilla Location Service). This is done in order to specify the location if the Cell Tower ID is not in the database or the positioning for a certain cell tower is not very accurate. The order of scanning external services is determined by the country to which the corresponding cell tower belongs. For example, Yandex has a higher priority for Russia, Belarus, Ukraine and Kazakhstan, while Mozilla – for Germany, Belgium and the Netherlands.

Google and Yandex services with local data randomizing are used for positioning via WiFi networks.

In addition to using external databases as information sources our service can itself collect anonymous indirect geolocation data and send them to the external services of OpenCellID and Yandex in order to improve their quality.

In order to provide higher fidelity the following rules have been introduced in the service so far:

- The positioning accuracy coefficient via the IP address is calculated depending on the number of IP addresses in the network in which the destination IP address is found.
- When positioning is done according to the data from cell towers one should take into account the previous measurement, performed several hours before the current one. This method allows reducing the probability of distorting the positioning if the cell phone operator changes the cell tower location.
- When positioning is done via the MAC address of a single WiFi network, one should also check the IP address from which the Internet access. The device address is not significant in this case, because it is assigned directly by the router and contains no useful information. If the country, determined by the IP address, is not the same as the one, determined by the WiFi network coordinates, saved earlier, such positioning is ignored and not used. This rule was introduced because of the fact that a user can access the Internet via the access point or a mobile router, which he always carries with him and therefore it is impossible to use their coordinates.

- When positioning is done via the MAC address of a WiFi access point, the AP vendor is also checked, and if it is one of mobile phones producers (Apple, Samsung, Nokia, HTC, etc.) such AP is ignored. Thus, mobile access points which, as a rule, have no fixed location are excluded.

V. CONCLUSION

At present the prototype of the indirect geolocation service is receiving practical approval. At the next stage of our research we are planning to analyze the mutual accuracy of initial data from different external services, used in our project, including those with respect to geographical regions. We are also planning to modify the applied service for improving geolocation quality for the purposes of mHealth applications and services.

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