A Location-based Social Network System Integrating Mobile Augmented Reality and User Generated Content

Yuanwen Yue
yueyuanwen@whu.edu.cn
Wuhan University
Hubei, China

Jiaqi Ding
16djq@whu.edu.cn
Wuhan University
Hubei, China

Yuhao Kang
yuhao.kang@wisc.edu
Geospatial Data Science Lab,
University of Wisconsin, Madison

Yueyao Wang
wyywyy16@pku.edu.cn
Peking University
Beijing, China

Kunlin Wu
Blanketzzz@163.com
Wuhan University
Hubei, China

Teng Fei
feiteng@whu.edu.cn
Wuhan University
Hubei, China

ABSTRACT

Location-based social networks (LBSNs) enable individuals to connect tighter through users' interdependency (e.g. friendship, common interests and shared knowledge) which derived from their physical locations and geo-tagged social media content. Nowadays, the development of mobile augmented reality (MAR) technology can enhance people's perception and interaction with the world, which enrich the way people share their geo-referenced information. In this paper, we propose a LBSN smartphone system by integrating MAR and user generated content (UGC). Users can publish their own content through an augmented reality (AR) form on a 3D model which is associated with real-world coordinates, and interact with content published by others. A prototype system is implemented on the iOS platform to prove the efficiency of the framework.

CCS CONCEPTS

• **Networks → Location based services**; **Social media networks**; • **Computing methodologies → Mixed / augmented reality**.

KEYWORDS

Augmented reality, social network, location-based service, user generated content

ACM Reference Format:
Yuanwen Yue, Jiaqi Ding, Yuhao Kang, Yueyao Wang, Kunlin Wu, and Teng Fei. 2019. A Location-based Social Network System Integrating Mobile Augmented Reality and User Generated Content. In *3rd ACM SIGSPATIAL International Workshop on Location-Based Recommendations, Geosocial Networks, and Geoadvertising (LocalRec'19), November 5, 2019, Chicago, IL, USA.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3356994.3365507

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

LocalRec'19, November 5, 2019, Chicago, IL, USA

© 2019 Association for Computing Machinery.

ACM ISBN 978-1-4503-6963-3/19/11…$15.00
https://doi.org/10.1145/3356994.3365507

1 INTRODUCTION

With the spread of GPS-embedded smartphones recent years, users can express themselves and expand their location-based social networks (LBSNs) through the creation of user generated content (UGC). LBSN serves as a platform for individuals to be connected through the interdependency (e.g. friendship, common interests and shared knowledge) which derived from their physical locations and their location-referenced social media content [18]. There are two challenges of current LBSN systems. First, the connections between locations and users, locations and media content still have room for improvement. For example, visitors can retrieve information about the place (e.g. history, cultural background, visitors' reviews, etc.) from the media content on the web while not by "where you are" at tourist attractions. The information is isolated from the real world and better human-environment interactions should be enhanced. Second, the traditional LBSN platform is usually limited to 2D social media content forms like text, picture and videos, while users' demand for diversification of media content is increasing.

Augmented reality (AR) system can supplement the real world with virtual (computer-generated) objects that appear to coexist in same space as the real world [1]. As a specific AR system which is executed by smartphones, mobile augmented reality (MAR) systems enable the coexistence of virtual and real objects in the meantime, while not restricting the individual's location. Ideally, MAR can work anywhere, adding a virtual layer of information to any environment whenever desired [6]. In this way, MAR systems enable users to create and interact with the computer-generated graphics which are spatially registered in the real world. Such interactive experience makes people access and understand location-based information and services easier [15]. In MAR environment, users can not only perceive and interact with the surrounding environment, but also cooperate and interact with other people, thus expanding the social network. More specifically, MAR can enhance LBSN for the following reasons.

First, MAR bridges the gap between the physical world and the virtual LBSN in cyberspace. It makes the physical world as "canvas" and "backdrop" of media contents, and brings social networks back to reality. In this view, the world becomes the user interface.

Second, unlike traditional media contents like text, image, and video in social networking services, MAR can enrich the form of location-based media content like 3D models, which are more impressive and attractive to users.

Third, MAR can promote interaction and communication among users. Users in the same MAR environment are more likely to have common interests and shared knowledge, thus enhancing the interdependency in LBSN.

Taking the advantage of MAR, in this research, we propose a LBSN smartphone system by integrating MAR and UGC. The system brings various benefits at two levels. At the application level, it allows multiplayer interactions and content interaction, extending the application form of AR. At the user level, the system enriches the way users spread content, which enables users to have more immersive social experience.

The remainder of the paper is structured as follows. Section 2 presents the related work about AR-integrated LBSN. Section 3 describes the proposed methodology. Section 4 introduces the interaction design and the prototype system. Section 5 concludes the paper and provides suggestions for further work.

2 RELATED WORK

Existing research has made efforts in the fusion of AR and LBSN at the theoretical level. In 2011, the term "Augmented Reality 2.0" was proposed by Schmalstieg et al. [16]. The goal of AR 2.0 is to provide widely applicable location-based AR experiences based on UGC which enhance creativity, collaboration, communications, and information sharing. Similar to the concept of AR 2.0, Liu and Gao [13] believed AR should be closely integrated with mobile Internet, social networks and location services under the concept of SoLoMo [5] to enhance people's social scene perception. In 2018, Liu and Fuhrmann [12] concluded the visualization, function, and ethics guidelines for developing and evaluating AR-integrated LBSNs.

Apart from this, numerous system applications, some of which have been commercialized, appeared. LibreGeoSocial[1] supports basic social networking and geo-tagging. However, the AR view contents of LibreGeoSocial are only 2D images. Sekai Camera[2] is a commercialized AR application which allows users to create only two-dimensional AR-based text messages, photos, and audio recording (called air tags). Users are able to interact with virtual objects created by other local users. However, these user-generated virtual objects are always visible in the social networks unless deleted by the creator. This unstructured information overflow brought many meaningless and outdated air tags, which contributed to the termination of the Sekai camera in 2013. Wallme[3] is another commercialized AR-integrated LBSN application. Similar to Sekai Camera, Wallme allows users to post virtual messages in the physical world and share with others. It also does not support 3D models, nor can users collaborate with others to create and modify AR content. Junaio[4] is a powerful AR browser which adopts optical tracking for 3D object rendering. However, the user needs to scan a specific 2d matrix or images with the camera to render the 3D model, which means that the 3D model is not associated with the real world coordinates.

Considering potentially large amount of data that may appear in popular locations, a processing system is needed for displaying UGC in relatively small screens. There has been numerous studies on investigating geo-tagged UGC data processing. In 2015, Bao et al. [2] discussed the new properties and challenges that location brings to recommender systems for LBSNs. Jiang et al. developed techniques to deal with top-k influential similar local query (TkISL) [7] and top-k local user search (TkLUS) [8] based on tweets with geo-tags. Li et al. [11] considered the similarity search problem which aims to find keywords with the most similar distribution of locations. Since location is an important component of UGC, Li et al. [10] investigated that how to infer the locations of non-geotagged tweets by scrutinizing Twitter user timelines.

From the above mentioned studies, several AR-integrated LBSN applications have been designed so far. However, the advantages of AR in LBSN are not fully utilized. In most previous works, the UGC superimposed on the reality view were 2D image or icon. Although some applications support 3D object rending, they require users to scan specific markers, which affects the user experience. Besides, little attention has been paid to the design of user-content interaction and user-user interaction. For the above reasons, we design a AR-integrated LBSN smartphone system with novel human-computer interaction mode. We also adapt a multi-factor based content filtering and updating strategy to promote high-quality content production in the region.

3 METHODOLOGY

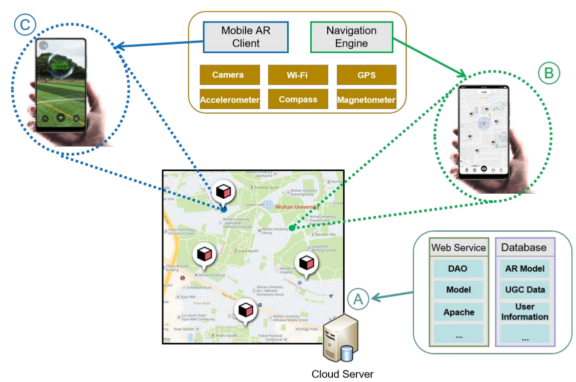


Figure 1: System framework and architecture

3.1 Client-Server Architecture Designing

The overall architecture is depicted in Figure 1. It consists of:

A) A cloud server (i) allowing the development of web service, and (ii) hosting the spatial database. The AR models, which are central to our architecture, refer to geolocalized visual 3D models combined with UGC data, which will be illustrated in section 3.2. Each AR model is associated with coordinates of latitude and longitude. To store these digitalized multimedia files, we use spatial database to attach the AR content to the physical world coordinates. The web service is used to process the requests from the MAR client.

[1] https://www.openhub.net/p/libregeosocial
[2] https://www.worldsummitawards.org/winner/sekai-camera/
[3] http://walla.me/
[4] https://en.wikipedia.org/wiki/Junaio

B) An embedded routing engine which can help users to find the location of AR models. The system retrieves AR models from the database and conducts route planning to guide users to the model.

C) A MAR client providing the following functions: (i) viewing of AR content; (ii) creating and publishing AR content; (iii) commenting on AR contents published by others. The MAR client refers to the smartphone with the AR viewing and interactions running on it. It requires basic hardware support to provide motion data for AR model tracking and positioning.

3.2 AR Model Designing and Positioning

The AR model consists of two parts: the AR content carrier and user generated content. We develop a set of content carriers, in which users can post 3D text, appeared as bubble, balloons, etc. These objects are designed as content carriers for two reasons. First, bubbles and balloons can evoke users' memories and emotions as they are good perceptual symbols [4]. Second, users can drag and touch the blowing bubbles and balloons to publish contents. Users can create various scenarios on these symbols with a sense of context, which can bring unique experience and feelings. For those users who are interested in existing AR models, they can tap on the model to comment. Combined with these user generated contents, an enhanced storytelling experience can be created. Multiple users can experience such enhanced immersion and social interactions [12].

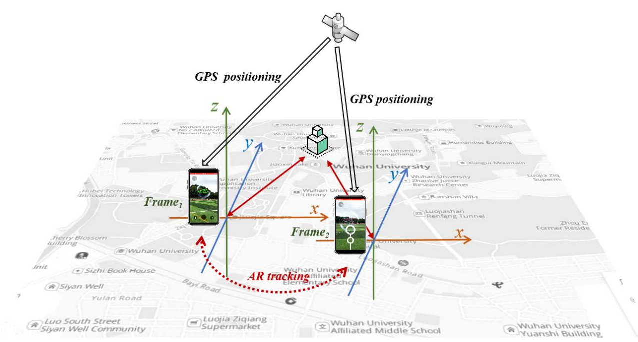


Figure 2: Positioning combined with GPS and AR tracking

The AR model should be positioned accurately so that it can support collaboration among many participants [17]. The main idea for positioning the AR model in real-world is to transfer the distance between two coordinate systems between the AR world and the physical world. In order to obtain a better performance when users move around, the system will take advantage of AR session's motion tracking data [14]. As shown in Figure 2, the user's real-time location is calculated based on the GPS and the relative moving distance acquired from the AR session. GPS data is used to provide rough location information, and then the AR tracking is used to refine the positioning accuracy.

3.3 Muti-Factor Based Content Filtering and Updating

One problem to be addressed in augmented reality display is information overflow due to the limited screen size of smartphones. Displaying redundant contents leads to poor user experience. A content filtering and updating strategy should be deigned to create a clear AR content layout and provide users with personalized content.

To solve the AR model overflow problem, a content filtering strategy is designed based on geographical distance, users' interests and relationships. First, we adopt a user-defined distance as the geographical constraint. The distance serves as a filter to return AR models that fall within the specified radius. Content outside of the radius will be removed. In order to satisfy users' interests, a series of pre-defined tags will be attached when users post content. The relevant content can be obtained more precisely by blocking uninterested tags set by users. Finally, a relationship filter is used to retain the AR models published by the users' friends.

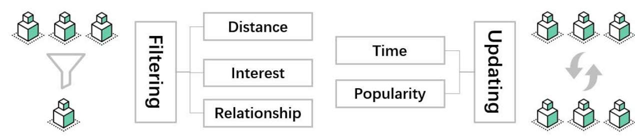


Figure 3: Content filtering and updating strategy

Several AR models will be replaced after a period of time to make room for new content. To increase the chance of interactions among users, we design an updating policy based on time and popularity. AR model published by a user will automatically disappear after a certain period of time unless it has high popularity. The level of popularity is calculated based on the strength of interaction, including 'likes', comments. The more 'likes' an AR content receives, the longer it will last, indicating that it contains high-quality UGC. This mechanism helps to retain high-quality UGC and remove the bad ones. More importantly, it can help the content within a region to update automatically and reflect the community's characteristics, such as common interests and concerns.

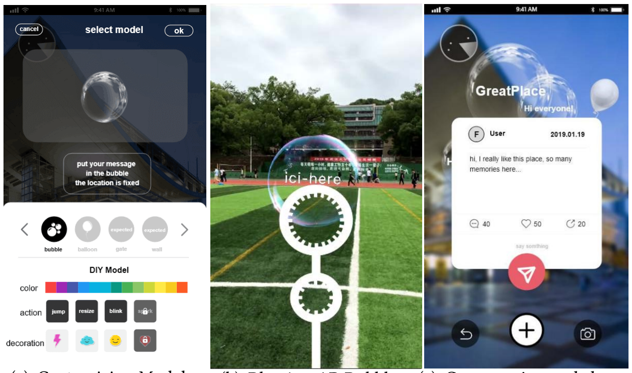
4 PROTOTYPE DESIGN

We design a prototype system on the iOS platform to prove the efficiency of the framework (iPhone 7 with A10 Fusion chip and 2 GB RAM). The implemented AR tracking and rendering service is based on ARKit SDK[5]. Server side, we use the Apache web service[6] which is deployed on Alibaba Cloud[7]. The following sections describe the interaction design which takes the advantage of MAR and UGC to enhance LBSN in the case system.

4.1 User-Content Interaction

Real-time interaction is an important feature of AR, and there are several common interaction types [3]: i) Traditional 2D graphical user interfaces (GUI); ii) 3D user interfaces (3D UI); iii) Tangible User Interfaces (TUI); iv) Body motion and gesture; v) Speech and sound interaction. Since the system is developed as an entertaining social platform, a series of interesting interaction ways are designed to enrich users' social experience.

[5]https://developer.apple.com/augmented-reality/
[6]http://ws.apache.org/
[7]https://www.alibabacloud.com/



(a) Customizing Model (b) Blowing AR Bubble (c) Commenting and sharing

Figure 4: User interaction interface

4.1.1 Tapping. Tapping is the way to trigger user-defined effects of AR models. To enrich users' UGC creation experience, as shown in Figure 4(a), users can attach various interactive effects to AR models like floating, bouncing, rotating, etc.

4.1.2 Pressing. An appealing bubble blower is designed to publish messages in AR scene. As shown in Figure 4(b), the system will adjust the size of AR models according to the time the screen has been pressed.

4.1.3 Voice Control. Sending messages in AR scene by blowing bubbles is a creative interaction design in the system and can be achieved by monitoring the mobile device's microphone. A floating action will be triggered if the system captures signal which is similar to a sound effect like blowing bubbles.

4.2 User-User Interaction

Kietzmann et al. [9] proposed a honeycomb framework that defines social media by using seven functional building blocks: identity, conversations, sharing, presence, relationships, reputation, and groups. In our system, we focus on the functionality of sharing, connection, and reputation.

4.2.1 Sharing. Sharing represents the extent to which users exchange, distribute, and receive content. In our system, as shown in Figure 4(c), users can leave comments and forward AR contents published by others.

4.2.2 Connection. Connection can be established by sharing and leader-follower mechanisms. Users can subscribe to popular AR content publishers which in turn enhances the sharing and connection functionality.

4.2.3 Reputation. Reputation helps to identify the status of users. In our system, users' reputation is reflected by the popularity of the content they publish. The more 'likes' a user receives, the higher the user's reputation, and the more followers the user may attract.

5 CONCLUSIONS AND DISCUSSIONS

The paper presents a LBSN smartphone system integrating MAR and UGC. The core components of the system include 3D modeling, positioning and a content filtering and updating strategy based on multiple factors. Users are allowed to publish location-based AR content in a 3D model and interact in a variety of ways, such as tapping, pressing, and voice control. A prototype system with novel human-computer interaction mode is implemented to prove the efficiency of the framework.

Future works are oriented for additional validations about the usability of the system and user evaluation. We also aim to build an automatic review of UGC by using deep learning algorithm to provide users with a positive social environment.

ACKNOWLEDGMENTS

This work was supported by the National Student Innovation and Entrepreneurship Training Program (No.201810486121).

REFERENCES

[1] Ronald Azuma, Yohan Baillot, Reinhold Behringer, Steven Feiner, Simon Julier, and Blair MacIntyre. 2001. Recent advances in augmented reality. *IEEE computer graphics and applications* 21, 6 (2001), 34–47. https://doi.org/10.1109/38.963459
[2] Jie Bao, Yu Zheng, David Wilkie, and Mohamed Mokbel. 2015. Recommendations in location-based social networks: a survey. *GeoInformatica* 19, 3 (2015), 525–565. https://doi.org/10.1007/s10707-014-0220-8
[3] Mark Billinghurst, Adrian Clark, Gun Lee, et al. 2015. A survey of augmented reality. *Foundations and Trends® in Human–Computer Interaction* 8, 2-3 (2015), 73–272. https://doi.org/10.1561/1100000049
[4] Wilbert O Galitz. 2007. *The essential guide to user interface design: an introduction to GUI design principles and techniques.* John Wiley & Sons.
[5] Gerrit Heinemann, Christian Gaiser, et al. 2015. Social-Local-Mobile. *Management for Professionals* (2015).
[6] Tobias Höllerer and Steve Feiner. 2004. Mobile augmented reality. *Telegeoinformatics: Location-based computing and services* 21 (2004).
[7] Jinling Jiang, Hua Lu, Pengfei Li, Gang Pan, and Xike Xie. 2017. Finding Influential Local Users with Similar Interest from Geo-tagged Social Media Data. In *2017 18th IEEE International Conference on Mobile Data Management (MDM).* IEEE, 82–91. https://doi.org/10.1109/MDM.2017.21
[8] Jinling Jiang, Hua Lu, Bin Yang, and Bin Cui. 2015. Finding top-k local users in geo-tagged social media data. In *2015 IEEE 31st International Conference on Data Engineering.* IEEE, 267–278. https://doi.org/10.1109/ICDE.2015.7113290
[9] Jan H Kietzmann, Kristopher Hermkens, Ian P McCarthy, and Bruno S Silvestre. 2011. Social media? Get serious! Understanding the functional building blocks of social media. *Business horizons* 54, 3 (2011), 241–251. https://doi.org/10.1016/j.bushor.2011.01.005
[10] Pengfei Li, Hua Lu, Nattiya Kanhabua, Sha Zhao, and Gang Pan. 2018. Location inference for non-geotagged tweets in user timelines. *IEEE Transactions on Knowledge and Data Engineering* 31, 6 (2018), 1150–1165. https://doi.org/10.1109/TKDE.2018.2852764
[11] Zhe Li, Yu Li, and Man Lung Yiu. 2019. A Spatial Insight for UGC Apps: Fast Similarity Search on Keyword-Induced Point Groups. In *2019 20th IEEE International Conference on Mobile Data Management (MDM).* IEEE, 371–372. https://doi.org/10.1109/MDM.2019.00-26
[12] Chengbi Liu and Sven Fuhrmann. 2018. Enriching the GIScience research agenda: Fusing augmented reality and location-based social networks. *Transactions in GIS* 22, 3 (2018), 775–788. https://doi.org/10.1111/tgis.12345
[13] Jingnan Liu and Kefu Gao. 2013. Augmented Reality and Its Applications for Navigation and Location Based Service. *Geospatial Information* 11, 2 (2013).
[14] Michele Stoppa Marion Maerz. [n.d.]. Understanding ARKit Tracking and Detection. https://developer.apple.com/videos/play/wwdc2018/610. Accessed Feb 11, 2019.
[15] Michele Ruta, Floriano Scioscia, Saverio Ieva, Danilo De Filippis, and Eugenio Di Sciascio. 2015. Indoor/outdoor mobile navigation via knowledge-based POI discovery in augmented reality. In *2015 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT)*, Vol. 3. IEEE, 26–30. https://doi.org/10.1109/WI-IAT.2015.243
[16] Dieter Schmalstieg, Tobias Langlotz, and Mark Billinghurst. 2011. Augmented Reality 2.0. In *Virtual realities.* Springer, 13–37.
[17] Daniel Gallego Vico, Iván Martínez Toro, and Joaquín Salvachúa Rodríguez. 2011. Collaborative content generation architectures for the mobile augmented reality environment. In *Recent trends of mobile collaborative augmented reality systems.* Springer, 83–97. https://doi.org/10.1007/978-1-4419-9845-3_6
[18] Yu Zheng and Xiaofang Zhou. 2011. *Computing with spatial trajectories.* Springer Science & Business Media. https://doi.org/10.1007/978-1-4614-1629-6