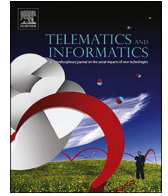


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# Smartphone user segmentation based on app usage sequence with neural networks

Younghoon Lee<sup>a,b</sup>, Inbeom Park<sup>a</sup>, Sungzoon Cho<sup>a,\*</sup>, Jinhae Choi<sup>b</sup><sup>a</sup> Department of Industrial Engineering and Institute for Industrial Systems Innovation, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742, Republic of Korea<sup>b</sup> Data Driven User Experience Team, Mobile Communication Lab, LG Electronics, 56 Digital-ro, Geumcheon-gu, Seoul 153-802, Republic of Korea

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## ABSTRACT

The term user segmentation refers to classifying users into groups depending on their specific needs, characteristics, or behaviors. It is a key element of product development and marketing in many industries, such as the smartphone industry, which employs user segmentation to gather information about usage logs, to produce new products for such specific groups of users. However, previous studies on smartphone user segmentation have been primarily based on demographics and reported usage, which are inherently subjective and prone to skew by the observers and participants. Hamka et al. (2014) was the first to conduct a study, in which smartphone user segmentation was performed using log data collected through smartphone measurements. However, they focused only on network usage and the number of apps used, and not on characteristics or preferences. In this study, we proposed novel ways of segmenting smartphone users based on app usage sequences collected from smartphone logs. We proposed a variant of seq2seq architecture combining the advantages of previous deep neural networks: neural embedding architecture and seq2seq architecture. Furthermore, we compared the user segmentation results of the proposed method with an answer set of segmentation results conducted by domain experts. These experiments demonstrated that the proposed method effectively determines similarities between usage sequences and outperforms existing user segmentation methods.

## 1. Introduction

The term user segmentation refers to classifying users into groups depending on their specific needs, characteristics, or behaviors to identify those who might require separate products or services (Kotler and Armstrong, 2010). Users can be segmented in different ways. One way is to characterize the target customers by homogeneous preferences, that is, grouping together customers that have roughly the same preferences (Kotler and Keller, 2009). User segmentation has been identified as a key element of product development and marketing. For instance, with user segmentation, product/service developers can develop differentiated and personalized products/services for each segment, and marketing personnel can create segmented advertisements and marketing communications for each segment.

Applying user segmentation strategies for information gathering is highly beneficial, particularly in the smartphone industry. First, smartphones have the capability to collect and store various types of information, including the user's location, communications, social networks, and lifestyle, which are effective sources of user segmentation (d'Alessandro and Trucco, 2011). Second,

\* Corresponding author.

E-mail addresses: [yhoon.lee@dm.snu.ac.kr](mailto:yhoon.lee@dm.snu.ac.kr) (Y. Lee), [ibpark@dm.snu.ac.kr](mailto:ibpark@dm.snu.ac.kr) (I. Park), [zoon@snu.ac.kr](mailto:zoon@snu.ac.kr) (S. Cho), [jin.choi@lge.com](mailto:jin.choi@lge.com) (J. Choi).

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hundreds of applications are often installed in a user's smartphone, and a log of their application usage is a powerful resource for user segmentation because it contains meaningful information regarding the user's preferences, behaviors, interests, and even demographic information, such as age, gender, and occupation.

In spite of these benefits that smartphones have with regard to user segmentation, previous studies on smartphone user segmentation have typically been based on demographics and reported usage, which are inherently subject and prone to skew by the observers and participants. Furthermore, those studies were predominantly performed by domain experts, who already have comprehensive domain knowledge and background information of the smartphone industry. Therefore, user segmentation tasks based on previous studies are expensive and time consuming because they require participants, who report their usage data to be gathered, and domain experts to analyze the participant's reported usage. Even if the scope of recent segmentation research was to be extended to behavioral segmentation utilizing the actual behavior of users and psychological segmentation utilizing the user's needs, intentions, and motivations, the data sources would still be limited to observed usage, and analysis by domain experts would still be required.

Hamka et al. (2014) was the first to study smartphone user segmentation using log data collected through smartphone measurements. They collected smartphone log data using a measurement application that ran in the background of the smartphone. They were able to segment 129 participants into six clusters utilizing their number of calls, messages, data usage, and the number of applications run per day. This was meaningful with regard to utilizing the log data of smartphones. However, they focused only on network usage and the number of apps used because their resource of analysis and segmented user was based only on their degree of usage, and not on their characteristics or preferences. Therefore, their study fell short of real business applications, which would require the user segmentation to be based on the user's characteristics and preferences.

In the smartphone industry, user segmentation is typically performed based on the user's preferences, interests, or willingness to use. Furthermore, the applications used by each user are the most meaningful and interesting source of identifying a user's preferences and interests (Insights and Insights, 2017). Therefore, considering which apps a user uses and what patterns their apps are used in with regard to smartphone user segmentation is essential. In this study, we propose novel ways of segmenting smartphone users based on their app usage log collected from LG smartphones.

We apply a neural network method, a variant of the sequence-to-sequence (seq2seq) architecture method, which is suitable for the smartphone app usage sequence, to improve the analysis accuracy of the app usage sequence. Our proposed method combines the advantages of two deep neural network models: the neural embedding architecture and the previously established seq2seq architecture. First, the neural embedding architecture is designed to represent words or documents by predicting the context word with the neural network. However, this architecture has a limitation trained to consider only words within the specific window size, as opposed to the entire sequence. Second, the existing seq2seq architectures usually consider the entire sequence in the training step. However, they are designed to generate corresponding sequences and not to represent the sequence itself, which is required for user segmentation.

Therefore, in this study, we propose a variant of the seq2seq architecture to represent each app usage sequence, which processes a whole sequence, and not within limited windows, and represents the sequence itself, and not the corresponding sequence. We then calculate the vector representation of each user based on the representation of each app usage sequence and derive the segmentation results by clustering the representation of each user. Lastly, we compare the segmentation results of our proposed method with the results of the segmentation carried by the domain experts in LG Electronics as an answer set to verify the performance and utilization of our proposed segmentation method. Furthermore, we calculate the similarity of our answer set with those of previous studies as a benchmark. The answer set of the user segmentations conducted by the domain experts consists of ten segments, including Conversationalists, Utilitarians, Social stars, Photographers, Music lovers, News and magazine readers, Video streamers, Gaming buffs, Power users, and Beginners.

The rest of this paper is structured as follows: Section 2 discusses various studies on the smartphone user segmentation and neural network method we utilized herein; Section 3 proposes our user segmentation method based on neural networks; Section 4 presents the data description and experimental results for the segmentation using the proposed method; and Section 5 provides the conclusions and the discussion, as well as the directions for future work.

## 2. Literature review

### 2.1. Smartphone user segmentation

User segmentation is an essential element of marketing and product/service development that considers the customer's needs and recognizes the heterogeneity of those needs. Kotler (2003) claimed that a company marketer can create a more fine-tuned product, service offering, and price appropriately for the target segment (Cravens and Piercy, 2006) using segmentation. He also suggested that in addition to improving service offerings and prices, companies can provide better distribution and communication channels to the target segment. Furthermore, fewer competitors are focusing on the same segment because companies often focus on a small portion of a customer group within a segment type, thereby reducing the level of competition.

User segmentation can be classified into several types: (1) geographic segmentation based on dividing the market into different geographical areas, such as nations, regions, cities, etc.; (2) demographic segmentation based on age, gender, family size, etc.; (3) psychographic segmentation based on social class, lifestyle, and/or personality characteristics; and (4) behavior segmentation based on occasion segmentation, benefit segmentation, service usage, and intention to use (Schejter et al., 2010; Chua et al., 2011).

The smartphone industry stands to benefit from user segmentation more than other industries because smartphone users are more integrated with their phones and possess different values, needs, and characteristic in adopting, using, or purchasing their

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