A Concept for Smart Transportation User-Feedback utilizing Volunteered Geoinformation Approaches

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Abstract. Public transport systems – especially demand responsive transport – lack a direct feedback possibility for customers. Contemporary approaches allow post-mortem feedback, where the consumer has to input detailed data of past travel experiences. Hence, it is hard to detect the location and time when and where the feedback was submitted, and in particular it is hard to trace the location of the incident that leads to the feedback (e.g. on which line/route, on which exact train the incident happened). Therefore we propose an approach for submitting feedback, that utilizes the current position of the customer. The approach draws on Volunteered Geographic Information (VGI), which is a special case of user–generated content coupled with participatory approaches in Geoinformation. Thus, the approach followed in this paper presents a concept that allows instant feedback, including the current position and timestamp. This approach allows the instant detection "where" an incident happened leading to costumer feedback (e.g. on which train, on which bus). A pilot implementation is tested and critically evaluated in a test region located in the municipality of Gratwein–Straßengel (Province of Styria, Austria). The experiment is conducted in a demand responsive transport system, where we monitor the feedback behavior of the customers using a smart-phone feedback application. The results show, that the concept utilizing VGI–methodologies was successfully applied to a demand responsive transport system. In addition, the results show that the approach provides instant feedback on problems and incidents for decision makers and transport managers, including the crucial information "where" and "when" something happened. In the first two weeks of operation, we received 55 customer feedbacks – of 175 ordered trips – of which the majority was positive and requested the transport service to be expanded in future.

Keywords: Volunteered Geographic Information, Citizen Science, public transport

1 Introduction

Volunteered Geographic Information (VGI) are present in a wide variety of feedback or information applications, whether it is for cleanliness in cities, damages

or defects of public property, dangerous spots in bicycle traffic or maybe a cycle route which is experienced as positive [21]. And yet, during a journey with public transport systems, there exist several difficulties to give direct feedback to the service provider - especially "where" and "when" an incident happened. Often, the issues the customer would like to put forward, are forgotten by the end of the trip or shortly afterwards. In this paper we make an approach for a real-time feedback system, which is based on VGI approaches, to detect "where" and "when" the feedback was provided. Therefore we developed an application tailored for customers of a demand responsive transport system in the municipality of Gratwein–Straßengel.
A demand responsive transport system is a special type of public transport, which is offering sustainable and independent mobility solutions for rural population [17]. It is not limited by the classical modus operandi of public transport systems, like given predefined routes and a fixed schedule.
Since the Word Wide Web was invented, it developed from static document-based information to dynamic high–performance and user–friendly services and finally evolved into a machine-readable web of data. Today the Internet is called "Web 3.0" or Semantic Web [3, 4]. The term VGI was first described by Michael Goodchild in his publication "Citizens as sensors: the world of volunteered geography". Through the evolution of the Internet to Web 3.0, users can contribute to data collections that are open to the public as well. As a result user–generated–content projects are on the rise since then [7]. Popular examples of such projects are Wikipedia or OpenStreetMap (OSM) [10]. VGI therefore is a special type of user–generated–content in particular user–generated–geographic–content, where people voluntarily apply there position. The three most frequently used methods of VGI are

- Base Mapping Coverage
- Emergency Reporting
- Citizen Science [5].

Due to length restrictions, Base Mapping Coverage and Emergency Reporting cannot be described here, we focus on Citizen Science (CS). The term CS describes the involvement of communities for scientific purposes [12]. Hakley named different types of CS, where he listed crowdsourcing as most common one is. In this case people act as sensor and provide data for companies or scientific purposes [11]. An example for CS is the e Audubon Society's Christmas Bird Count, conducted by non-professional ornithologists.

Hence, we decided to utilize CS - in particular crowdsourcing - in public transport systems - and in particular in demand responsive transport systems. In our case the customers will provide the data in form of real–time feedback. This is approach is utilized to determine whether VGI is helpful for getting feedback for planning and decision making purposes in demand responsive public transport. The paper is organized as follows. Section 2 gives an overview of related work, which uses VGI in public transport or traffic management. Section 3 elaborates on the research design and methods used to provide and prepared the data. Section 4 presents the field test and the prototype framework. Finally the results, evaluation and interpretation are presented in section 5. In section 6 we give a conclusion and some future research directions on how VGI can be utilized in public transport.

2 Related Work

Verkehrplus[20], Nunes[14] and Teymurian[19] used approaches for getting real-time feedback which are very similar to the one in this paper. Especially the works of Verkehrplus and Nunes present examples for applications enabling real–time feedback, including position and timestamp of the feedback. The prototypes were tested under real-world conditions in the Province of Styria, Austria and in the City of London. By contrast, [19] developed a conceptual framework, based on a cooperation of VGI for quality measurement and an automatic data collection for performance measurement in public transport. Both data sets - quality and performance data should help to identify the weaknesses of existing public transport systems and help to find solutions for it.
Attard [1] and Steinfeld[16] described the potential of using VGI for collecting data in public transport. Filippi et al. [6] pointed out how crowdsourcing can be part of public transport planning. In this study the population are integrated into process of planning from the beginning until the full implementation of public transport solution strategies .
Apart from public transport other studies show how VGI can improve bicycle traffic in cities. Therefore, Griffin and Jiao [9] as well as Nelson et al. [13] demonstrated how the applications "Strava" and "BikeMaps.org" can help in planning and safety issues.

3 Research Design

The research design of the study is divided into four distinct phases: questionnaire design, smartphone application prototype, field test, data evaluation. The research design should help to answer the question if crowdsourced information is helpful for demand driven public transport.

First we developed a simple questionnaire that is tailored towards the usage in a mobile application. In addition, the questionnaire should be rather short, so that customers can finish it while driving with the public transport system. Also, we designed the questions in a way that they are easily understandable and do not require lengthly responses from the customers. Hence, we came up with 14 questions of which thirteen cover the following topics: personal data, mobility behaviour and whether the demand responsive system is going to be accepted by the rural population or not. The last question referred to the position and a timestamp - if it is accepted by customer that we track the position and the time of their response.

Secondly, we developed a smartphone application prototype that is presents the questionnaire to the customers and stores the feedback from them on a database server. The application prototype shall be tested in real-world conditions, in order to see if the crowdsourcing approach works in a demand responsive transport system. In addition, the test shall reveal, if the transport system is accepted by the rural population of the municipality Gratwein-Straßengel.

The analysis step involves a spatial-temporal analysis of the feedback obtained by the smartphone app. The evaluation and analysis requires analysis methods from Geographic Science and Technology (GIS&T) and a Geographical Information System (GIS).

4 Field Test and Framework

The field test was conducted in October 2017, the test subjects were the customers of the demand responsive transport system in a municipality in the north of Graz in Styria. the municipality of Gratwein-Straßengel has 13.000 inhabitants and covers an area of 86,69 km^2. The community is composed of the districts Gratwein, Judendorf–Straßengel, Eisbach and Gschnaidt, which are crossed by two railway lines and five bus lines. In order to provide a better connection for inhabitants who are not within reach of bus stops, train stations and district cores, the commune established a demand responsive transport system. The service time of the demand responsive transport is from Monday to Friday from 08:00 am to 07:00 pm.

The smartphone application to collect crowdsourced data, consists of a front- and a backend. The frontend utilized the jQuery framework for the layout and for the responsive design of the application. Java script functions were used for the positioning via GPS and for gathering the timestamp. Regarding to the positioning we use the "geolocation API" - an application programming interface, which determines the current position via GPS. If no GPS–signal is available the API utilizes cell towers, a wireless network or the IP–address to determine the position. The Backend of the application is based on PHP for the server connection and transmission of the data. A PostgreSQL/PostGIS database is used to store the data accordingly.

5 Results

The results of the study reveal the following results. First we elaborate on the where the feedback was sent, and the overall response rate. Secondly, we have a look at the customers and their usage of the demand responsive transport system. This is followed by an evaluation of the alternative mobility choices of the customers - if no demand responsive transport would have been realized.

The results show that 55 of 175 customers provided a feedback - which equals to a response rate of 31%. The position of each provided feedback is depicted in Figure 1. The customers that provided feedback are predominantly over 60 year of age. 35 of 55 persons that used the feedback application were over 60 years of age, which equals to approximately 64% of persons over 60 years (see Figure 2). More than 58% of the customers use the demand responsive transport system several times a week.

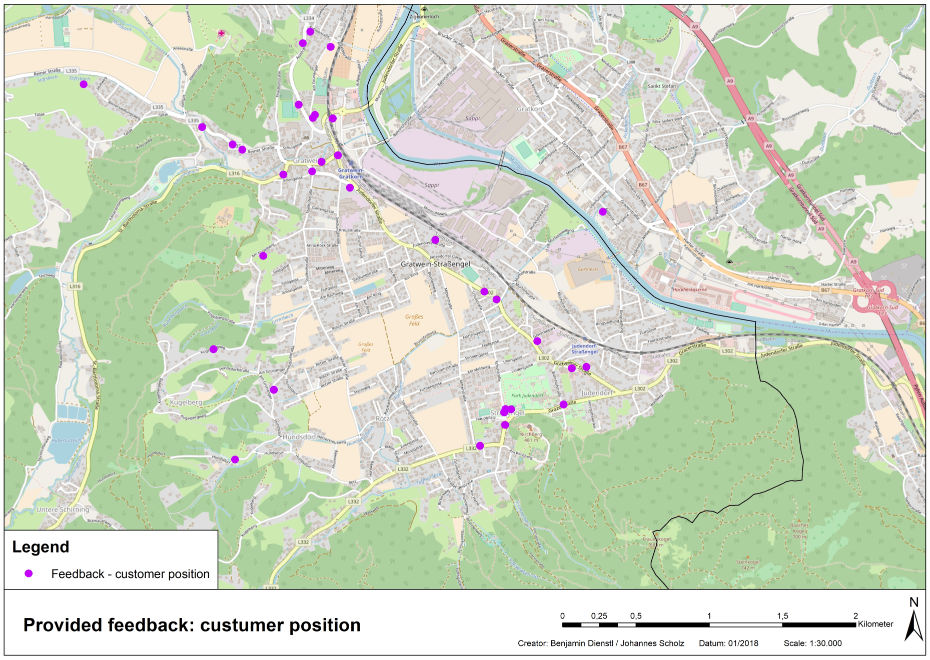

Fig. 1. Provided Feedback – customer position on a OpenStreetMap basemap.

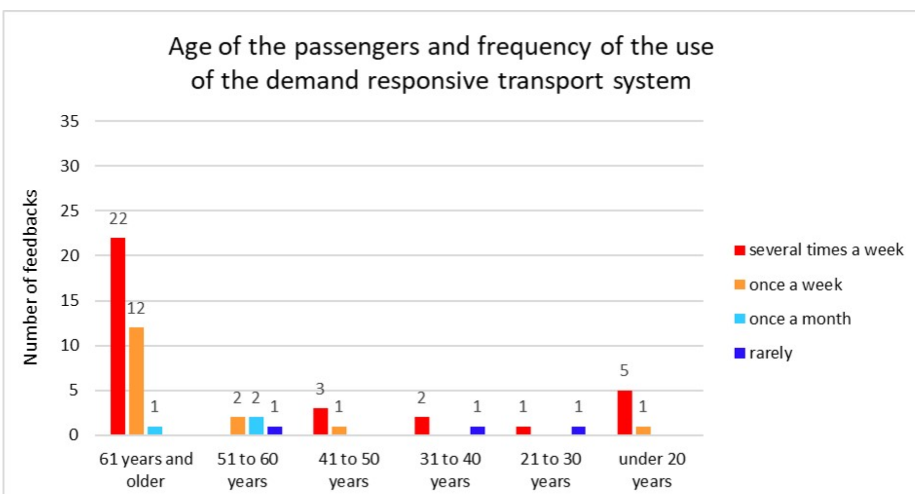

Fig. 2. Age of the passengers and their usage frequency of the demand responsive transport system.

The questionnaire also revealed the alternative mobility choices of the customers - in case the demand responsive system would not be in place (see Figure 3). Most of the responses show that there is no other public transport as alternative available. Eight persons responded that they would use their own car, 12 persons would use a car as passenger, and nine responders would have to use a taxi instead. Thus, 29 of 55 customers would use a car - i.e. private car, car as passenger, taxi - as alternative way of mobility. Interesting is the fact, that six persons are stuck at home without demand responsive public transport, only 4 could switch to public transport. Nine and seven persons could use their bicycle or walk on foot respectively.

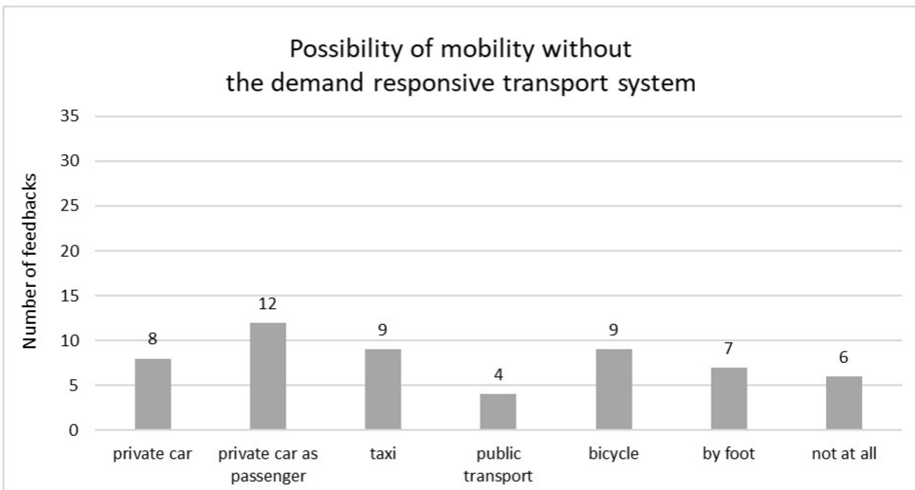

Fig. 3. Alternative mobility choices without the demand responsive transport system.

6 Discussion and Conclusion

This section is intended to discuss the results obtained - which are presented in section 5. In addition, we try answer the research question and draw conclusions from the findings of this paper.

The test of the feedback prototype in a period of two weeks shows that we received 55 customer feedbacks – of approximately 175 ordered trips within ten days which equals to 31% response rate. The feedback positions (see Figure 1) show that most of the feedbacks were provided in the districts of Gratwein and Judendorf–Straßengel. This is due to the higher population density in those areas, and the fact that shops and public authorities are located in this town centers. The results of the questionnaire indicate that most of the customers, who use the demand responsive transport several times a week are 61 years and older. The second largest user group are customers under 20 year of age. They are using the transport system to get home from school.

Worthwhile emphasizing is the fact that only four customers have the possibility to use any of the existing public transport systems. This means that from the provided feedback, 93% (in total 51) of the trips were newly generated trips (see Figure 3). Hence, we argue that an increased offer of public transport systems will generate new customers - here under the following conditions:

- The transport system is flexible enough to fulfill the travel demands of the customers (i.e. a demand responsive transport system).
- The customers do not have alternative means of public transport, which is especially true for rural areas (such as our test area).

With respect to planing and decision making with the help of a demand responsive system, we would like to highlight the fact that responses from customers can be directly used to improve the transports system. An example is the installation of additional benches and access aids, as customers are 61 and older. Furthermore the establishment of new stops in the district centers of Gratwein and Judendorf–Straßengel would be beneficial for older customers.

From the results obtained and the relevant literature, we can conclude that collecting feedback in public transport systems - especially demand responsive ones - with VGI–approaches seem to be a promising methodology. In comparison to conventional methods of collecting feedback, where customers have to visit the homepage and complete a short survey about their experience [8], the possibility to provide instant feedback, including "where" and "when an incident happened, may reduce the reaction time of transport managers. With the removal of entry barriers, the user requires a shorter period of time for the input and therefore providing feedback becomes way more user-friendly. This can be justified by a response rate of 31% in contrast to conventional methods of collecting feedback without any recruiting phase which are significantly lower [e.g. 2, 15, 18]. Hopefully this may motivate customers to provide feedback more often - even if only minor nuisances are detected, which might get forgotten in a post-mortem feedback system.

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