People go out together: a neglected context factor in pedestrian assistance systems

Bjoern Zenker

Chair for Artificial Intelligence
Friedrich-Alexander-University Erlangen-Nuremberg
Haberstraße 2, D-91058 Erlangen
bjoern.zenker@cs.fau.de

Abstract. Pedestrian navigation systems (PNS) are currently not as frequently used as navigation systems for cars. We think, this is due to the PNS's lack of considered context factors. In this paper we argue that actually the social contacts of the users are an important context factor for PNSs. Our argumentation is based on the results of two studies which we have conducted concerning outgoing behavior of humans. The results show that over 60% of all pedestrians in their leisure time go out in groups. Thus, PNSs should incorporate this important factor. We will present a novel PNS for groups (PNS4G), which allows a group of individuals to get assistance in meeting and navigation to a common goal, e.g. for going to the cinema.

1 Introduction

1.1 Motivation

Current PNSs are intended for single users only. They assist one user by helping the user to go from a starting place to a destination. But our everyday knowledge tells us, that this is often not sufficient, for example when you want to meet a friend who is situated at a different place than you. In such a case a meeting point must be found where your friend and you can meet and then proceed to your common destination.

For this setting, we can roughly identify two phases for which assistance can be provided. First, assistance can be given in the phase of making the appointment, e.g. settling on a time and destination. Second, assistance can be given for the navigation of all people involved in the meeting to their common destination. This includes finding appropriate meeting points and routes.

1.2 Outline

First, in Section 2, we will present the state of the art of PN for single users and groups of users and inspect the problem of measuring group sizes of people.

In the following section we will present our own studies which measured group sizes of pedestrians more accurate.

As most people go out in groups, we built a PNS which focuses on considering this important contextual factor. This system is presented in Section 4.

Finally we conclude in Section 5 and make a forecast on future work.

2 State of the Art

Current pedestrian navigation systems help pedestrians to find their way to their goals by giving turn-by-turn instructions. Today all pedestrian navigation systems known to the authors are for single users only. Examples of such systems are Google Maps Navigation, ovi maps, MobileNavigator, PECITAS [1], P-Tour [2], RouteCheckr [3], COMPASS [4] and many more.

One exception to these single user PNS is a prototypical PNS from [5] which helps people to meet. The system recommends a restaurant in an area which is reachable by all participants in time and helps them navigating to the restaurant by displaying some maps. No detailed information about this system is available in literature. For the special case of exactly two users the systems MeetMe (`http://aboutmeetme.com`) and MeetWays (`http://meetways.com`) recommend meeting points and routes. This is done by first calculating the shortest path between the two users and second recommending places of interest (POI) which are near to the middle of the calculated path.

While there exist numerous studies about animal group sizes, only few exist for human group sizes. One of the first studies about human group sizes originates in the year 1951, when James measured group sizes in politics and in public places, e.g. pedestrians, in department stores, playgrounds. In [6], James determines a mean group size of 2.41 people in informal groups. A total of 7405 groups have been studied. $71,07\%$ of all groups consisted of two persons, the other $28,93\%$ have been groups between three and seven persons. In this study, the counting of individuals has not been taken into account. The subsequent paper [7] declares a mean group size of $1,46$, if individuals are considered. James also deduced a generalized model of pedestrian group sizes from this data, but this model has been prooven incorrect by [8].

From James' data we can calculate, that 34.46% of all groups (including groups of size 1, namely individuals) are groups of two or more people. To a different result comes [9], who observed, that up to 70% of pedestrians in a commercial street walk in groups.

Note the difference between the latter two units of measurement. By converting James' result, we find that 55.14% of all pedestrians in James' study are in groups. Now one can easily see that the results of the two studies differ about 15%.

2.1 Crowding

There are various problems with measures of group sizes, as group sizes most of the time do not follow a normal distribution. [10] Hence, only statistical methods for non-normal distributed data may be used. Besides that, one has to distinguish measurements between Insiders' and Outsiders' View as Jarman noted in [11]. One finding which motivated this discrimination was that Jarman showed, that average individuals (Outsiders' View) live in groups bigger than the average individual (Insiders' View).[1]

The mean group size for the Insiders' View conforms to the arithmetic mean. Let $S = \{s_1, \ldots, s_n\}$ be a tuple of the measured group sizes $s_i \in S$.

$$\bar{s}_{out} = \bar{m}_{arithm} = \frac{1}{n} \sum_{s \in S} s$$

The mean group size for the Outsiders' View, called Typical Group Size according to Jarman or crowding according to [10], is calculated as the following.

$$\bar{s}_{in} = c = \frac{\sum\limits_{s \in S} s^2}{\sum\limits_{s \in S} s} = L_2(S)$$

In fact, this method of calculating a mean equals the second Lehmer mean L_2. As Jarman invented the measure crowding based on sociologic reasoning only, it is astonishing that he ended with this well know mathematical mean. To the knowledge of the author, this hasn't been noticed yet.

A short example will reveal the difference. Imagine that we have observed one group of size two and one group of size five. The Insiders' View group size calculates to $\bar{s}_{in} = \frac{2+5}{2} = 3.5$. If we do not only take into account the measured group sizes but the group sizes of all individuals in the groups, this conjures up another image: In the Outsiders' View, the average individual lives in a group of size $\bar{s}_{out} = \frac{2 \cdot 2 + 5 \cdot 5}{2+5} = 4,14$. This is an example which shows, that average individuals (Outsiders' View) live in groups bigger than the average individual (Insiders' View).

3 People go out together

As the studies of James are now more than half century old and not tailored to our specific subject of research, we conducted two studies of group sizes recently. The first study measured group sizes of people using means of public transportation. The second study measured group sizes of pedestrians and people in shopping malls, restaurants and other places of public life. After the discussion of these two studies we will compare and interpret their results, also with regard to ' findings.

3.1 Groups using Public Transportation

In a diary study about information needs of public transport users we asked the participants questions about the group size in which they were travelling. 10

[1] Except the case in which all groups have the same size.

participants completed a total of 188 rides with means of public transportation in the area of the metropolitan area of Nürnberg.[2] 16.07% of all rides have been conducted in their leisure time, 74.40% in their time for business and in 12.50% people had to settle an affair. 80.95% of all participants rode alone and had no meeting with other people planed, 7.14% rode alone and had a meeting planned, 5.36% rode in a group and had a meeting planned and 6.55% rode in a group and had no meeting planned.

The average group size (Outsiders' View) was 1.19 individuals. (1.06 individuals per group travelling for business and 1.81 individuals per group for leisure.) Considering only groups of two or more individuals, we get 2.60 individuals per group (2.00 individuals per group travelling for business and 3.20 individuals per group for leisure). Looking at the group size distribution of the leisure subgroup one can see smaller and bigger groups occur more often than groups of middle size. We think this is due to the limited amount of participants and recorded rides.

88.10% of all participants were riding alone, 11.90% were riding in a group. If we consider all people who were riding in a group or wanted to meet more people, we come to the result that 19.05% of all people using public transport are potential users for a PNS4Gs. Now, let us only examine rides for leisure. There, 37.04% of all people traveled in a group and 62.96% traveled alone. From the people traveling alone, 35, 29% wanted to meet other people. This results in 59, 26% potential users in the leisure subgroup. (8, 80% in the business subgroup.)

By reason of the limited number of participants and rides, this study has only a small informative value.

3.2 Group sizes of pedestrians

We conducted a second study to measure group sizes of pedestrians and people in public places like shopping malls and restaurants. This study was oriented at the setting of [6] and measured the frequency of group sizes at different places in the city of Erlangen, Germany (105.157 inhabitants). 992 observations of group sizes were logged.

Only groups of people have been logged, which apparently did not pursue a job task. People belonged to a group when they where talking or interacting with each other or walking together. Small children, who seemed to be not able to walk through the city alone, have not been counted. Observed frequencies have been recorded with a specially developed application on a smartphone, see Figure 1. That way, the observer could easily note frequencies while observing pedestrians at the same time. The observations "restaurants and coffee shops", "shopping center 5pm" and "pedestrian zone" have been conducted on a Saturday in April, while the other observations have been conducted on a Wednesday in April the same week. In the future we want to conduct more observations in different locations, on different days and times of the day.

[2] Some rides have been logged by multiple participants who travelled together. These rides are assessed in this analysis only once.

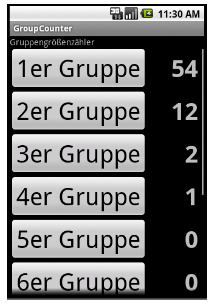

Fig. 1. Application for logging group size frequencies

group size frequencies	1	2	3	4	5	6	7	m	g
James 1953	65.54%	25.47%	6.94%	1.54%	0.42%	0.09%	0.00%	1,46	1,84
public transportation	62.22%	22.22%	3.07%	0.00%	3.07%	7.41%	0.00%	2,14	3,30
restaurants and coffee shops	11.30%	62.61%	20.00%	4.35%	0.87%	0.87%	0.00%	2,23	2,53
shopping center 5pm	47.74%	41.46%	6.62%	2.44%	1.74%	0.00%	0.00%	1,69	2,11
shopping center 7pm	51.43%	33.21%	12.50%	2.14%	0.71%	0.00%	0.00%	1,68	2,08
pedestrian zone	57.97%	36.96%	4.35%	0.00%	0.72%	0.00%	0.00%	1,49	1,77
in front of shopping center	63.95%	25.58%	6.40%	0.58%	1.74%	1.16%	0.58%	1,56	2,22
suburban building center	65.85%	32.93%	1.22%	0.00%	0.00%	0.00%	0.00%	1,35	1,54
busstop	78.26%	15.94%	2.90%	1.45%	1.45%	0.00%	0.00%	1,32	1,73
suburban street	82.52%	13.59%	3.88%	0.00%	0.00%	0.00%	0.00%	1,21	1,42
total (excluding James & pt.)	46.48%	39.96%	9.97%	1.90%	1.16%	0.41%	0.12%	1,73	2,14

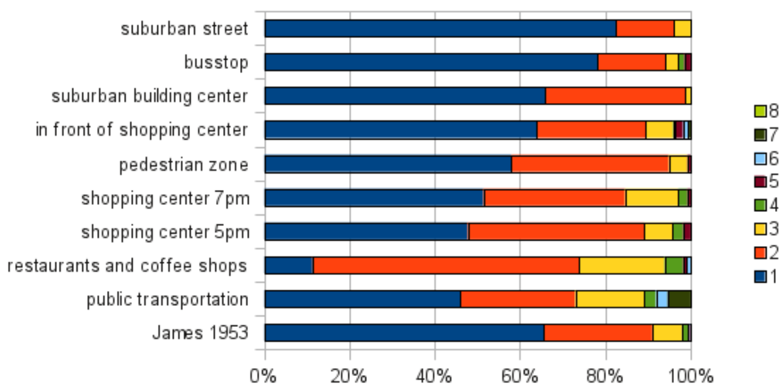

Fig. 2. Observed group size frequencies, Insiders' (m) and Outsiders' (g) mean group sizes. For easy observation a chart displays the group size frequencies.

Table 2 shows an overview of the different observed places and frequencies. For means of comparison, also the data of the study from [7] and the study from the last section is shown. This data was not included in calculating averages and total sums.

We can see that on average 53.52% of all observed groups in this study are groups consisting of 2 or more individuals. This means, that 60.01% of all observed *people* have been in groups. In restaurant and coffee shops, the average group sizes exceed group sizes in the other observed places. Bus stops and the suburban street have the smallest average group sizes.

3.3 Comparison and Interpretation

The average group sizes for bus stop and the public transportation study seem not to correlate. We interpret this as an indicator, that further studies with greater samples have to be conducted. Especially the public transportation study seems biased due to an unexpected high average group size. Our result is more close to [9] who found, as mentioned, that up to 70% of all people are walking in groups. Note that James came to a different result. This might be due to the different places of observation used in both studies. Our study focused on places, where people spend their free time, while James examined a broader variety of places. Another explanation would be, that outgoing behavior has changed in the last 57 years and today more people go out together.

The observation that over 60% of people go out in groups fortifies our assumption, that this contextual factor is so important, that it should be incorporated in PNSs. The next section shows how we built a PNS4G which considers this and gives assistance to groups of people who want to go out.

Of course, measuring group sizes is not a proof that people meet. They could be all families that have started as a group at home. But it is a good indication that people meet. Group sizes in places like restaurants and shopping malls are higher than group sizes in streets and means of transportation. Unless bigger groups tend to use means transportation which have not been observed (like cars), this is a strong indication, that people meet.

4 Integrated Appointment Assistance and Group Pedestrian Navigation System

We have identified two main phases of going out. In a first phase, the *appointment phase*, the destination and the time to meet have to be agreed upon. In the following *meeting phase* individuals proceed to the common destination. There exist more phases, but we focus in this paper on the two presented. For appointment phase and meeting phase we built two assistance systems.

The meeting assistance system consists of two subsystems, the Appointment Assistance System (AAS) and the Group Pedestrian Navigation System (GPNS). AAS helps individuals in the appointment phase to agree on a destination. After having settled on a destination, the meeting phase begins: routes for all individuals are calculated. These routes are not only routes directly from each individual to the destination, but routes where individuals meet at intermediate points on their way to the destination. Both systems are presented in the subsequent subsections.

Currently, AAS and GPNS are coupled loosely. After the destination is settled upon, the result is passed to GPNS as input. For more elaborate systems in the future, characteristics of the group route (GR) should be considered also in the appointment phase.

Both systems extends the PNS ROSE [12] and can be used using one single client, currently running on mobile phones with Java Mobile Edition. The client communicates with a J2EE server using JSON over HTTP. The server stores user profiles, friends lists and events lists in a database. Also the server offers services such as geocoding, route generation for pedestrians with support of public transport and recommendation of events.

4.1 Appointment Assistance System

The AAS assists groups of individuals settle on a common destination. As we cannot rely our design on experienced data we build a flexible system which allows several task flows to be implemented. We then compared task flows to find an appropriate task flow for our scenario. The task flow of the user to user interaction can be modeled in different ways. We implemented different task flows and evaluated them. By using this method, we examined which user to user interaction work flow is best. A detailed description of this system is out of the scope of this paper.

4.2 Group Pedestrian Navigation System

After a settlement is achieved our system helps the individuals to navigate to the agreed destination. For this, the current positions of the participants and the destinations are passed to the GPNS.

One can easily imagine, where the participants could meet: at the destination, at one of the participants homes or at some dedicated locations in between. Often, the latter is the case: People meet at intermediate locations to yield a good compromise between detour and conjoint travel.

To model this behavior we reduced the problem of finding satisfying meeting points to the Steiner Problem. Various versions of this problem exist, but the essence of this problem is to "Find the shortest network spanning a set of given points..." [13]. In [14] we discuss the calculation of meeting points and routes for multiple people based on two versions of the Steiner Problem in detail.

After calculation in the server, the routes are sent to the participants mobile phones. There, routes are displayed and allow turn-by-turn navigation for each user. Figure 3 shows the client of a user who is going to meet shortly another user. To facilitate meeting, positions of users are updated on the screen almost in real-time. Meeting points could be dynamically recalculated, but as this might be confusing to the users, the current implementation does not employ this feature. After meeting they will continue their journey to their destination conjoint. An overview map of the routes of two users in the city of Berlin and their meeting point (pink) can be seen in Figure 4.

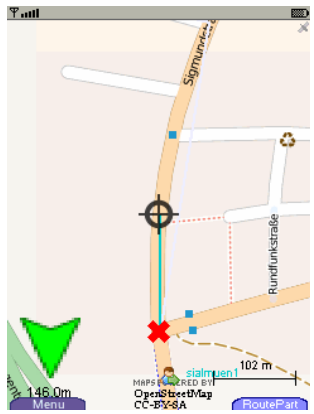

Fig. 3. Screenshot: User (cross hairs) will meet his friend (user icon) soon at the meeting point (red cross).

5 Conclusion and Future Work

There are several contextual factors which still have to be integrated in PNSs. We identified the social contacts of the users as one important factor. This is due to the finding, that over 60% of all pedestrians go out in groups together. Because people visit most events and locations together, supporting groups of users will become one major challenge for future developments of PNS. To consider this finding in pedestrian navigation, we built an integrated appointment assistance and group pedestrian navigation system.

Currently we are collecting more data for the two studies to ensure more reliable results. We have also work ongoing, which allows not only to create walking routes for groups, but also to take means of public transportation into account. Furthermore we are developing an HTML client to allow more users use the system and to carry out extensive user studies.

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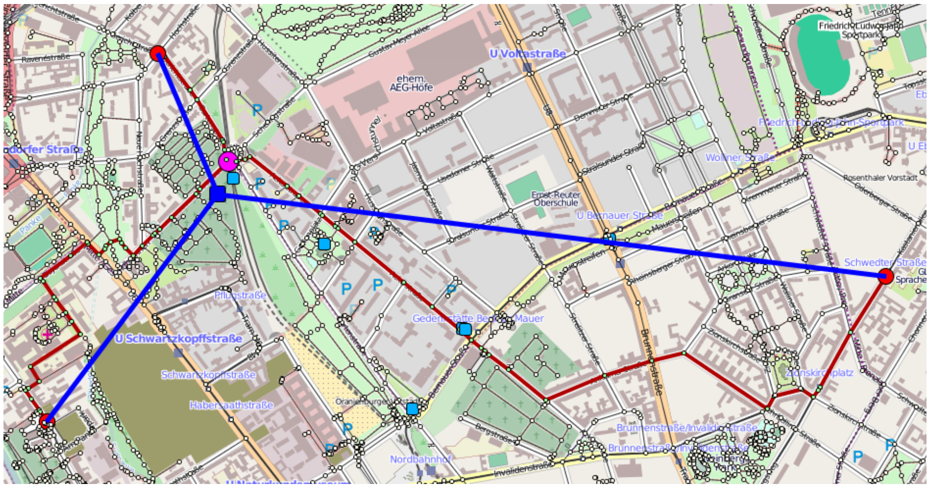

Fig. 4. Two users and their meeting point (pink, in the middle) for their way to a destination, based on the assumption, that positions of destination and starting position of users are interchangable. (Map from OpenStreetMap CC-BY-SA, as seen in [14])

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