1. Introduction

AGILE instructions for the preparation of a 2-column-format camera ready paper using MS Word XML (.docx)

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Abstract

These pages provide you with instructions on how to use this MS Word template to prepare your paper according to the required layout and style for AGILE conference papers. The abstract should be concise and no longer than 250 words.

*Keywords*: Please select a maximum of 6 keywords.

In urban traffic, road users are often found moving in groups. These groups can be formed for different reasons. For instance, social connections (e.g. friends, couples, families) between pedestrians; mixed groups formed by traffic regulations, i.e. road users who follow the same phase of traffic lights, etc. The members of the same group interact differently to other road users in comparison to individuals [1], and they tend to keep similar speed and appropriate distance.[4]

An obvious benefit that comes from grouping is safety. Being in a group creates a buddy system where people can look after one another on the streets. \cite{jacobsen2015safety} found that people walking and bicycling in larger groups are less likely to be injured by motorists because the motorists are more cautious with groups. It will also have a beneficial effect on traffic planning: if groups are formed, this leads to an reduction in the number of road users that have to be included in computations, thus leading to a decrease in computational complexity for later applications, e.g. for traffic simulation and pedestrian navigation.

Although forming groups are common and natural for road users in normal traffic senerios, there is only very few researches on how to form groups in the shared space, where the traffic features (e.g. curbs, zebralines and traffic lights) are removed to minimizes demarcations between vehicles and pedestrians. Some studies suggested an increased risk at higher traffic volumes in shared spaces \cite{quimby2010review}, \cite{reid2009dft}. Later, \cite{holmes2015accident} launched a survey to find out about people’s experiences of using shared spaces in towns and cities. Pedestrians felt strongly that drivers did not recognize a shared space and were not slowing down to allow people to cross. Problems were pronounced in areas with high volumes of traffic or through traffic. Apart from safety aspects, currently shared spaces have efficiency problems as well: the bottleneck effect happens when traffic density is high. With the backgroud above, we can conclude that the formation of road user groups before and during crossing will improve the safety and efficiency in shared spaces.

However, how to form groups is not a trivial task in shared spaces. Firstly, the traffic signs are removed from the road surface, therefore, the location and number of groups should be decided, which is different from most area traffic management methods[]. Secondly, the area traffic regulation systems, like SCTOOT and GJ are not really online or dynamic. It learns regulations from historical data, and keep it as fixed periods. However, in shared spaces, the coming and leaving spots could be very different in different time periods, therefore, a dynamic algorithm is needed for road users here. Last but not least, even a single pedestrian group can gain or lose members on the fly due to interactions with other single road users or groups [13], the so-called splitting and merging phenomenon. The methods should take the coexistance of users trajectories into condideration.

Group behaviors have been studied in computer graphics [HLLO10], [CSM12], robotics[KLB12], pedestrian dynamics [GBS14], and social psychology [S.73]. Early techniques have been mainly used to simulate static or fixed-sized groups and perform group-based collision avoidance [SC14], [Lv13], [KG15]. Group initialization has also been addressed. [SKM17] simply used a threshold based on the distance between the team leader and members to group the pedestrians with similar OD. However, this approach is sensitive to the order of the input data because the algorithm is greedy - once the first possible solution is accepted, other solutions will never be reconsidered. [HPN + 16] clustered the original groups by the pairwise similarity metric defined over agents based on their starting positions and velocities. This works for the simulation application because the agents who are together at the beginning will keep coherent until the end of the experiment. However, the traffic scenario is more complicated. E.g. the road users who have the same origin and velocity at the beginning may split and reach different goals later. [HKBK14] considered the dynamic group behaviors via specifying the group shape as a queue and give deformation penalty, which is effective but cannot be generalized to other group shapes. However, none of these methods can efficiently simulate heterogeneous groups with dynamic behaviors in arbitrary environments.

We concentrate on the following application scenario: Road users can appear from random locations around the shared space, then pass through, finally leave to their destinations. We are searching for a clustering algorithm to assign those road users to several groups according to their origins, destinations, time and trajectory shapes. Here, a group is a formation of road users moving in a coordinated manner. A group can split, merge, avoid collisions while moving (\cite{mihaylova2014overview}).

1. Methodology

In the following we present a definition suitable for shared spaces. Assuming a stream of road users who come continuously and independently from all the directions of a shared space. For each road user, the coordinates of its origin (ox,oy), destination (dx,dy) and appearance time (t) are known. All road users have a static waiting time (w) before crossing , a number (h) to take historicle data before computation, and a threshold to estimate the data points similarity (f). The goal is to find an dynamic algorithm to cluster the road users who has similar oringin and destination before they are tired of waiting.

The problem above can be formulated as a series of facility location problem. In a basic formulation, the facility location problem is the following: giving a set of demand points and a set of candidate facility sites with costs of building facilities at each of them, the goal is to select a subset of sites where facilities should be built. Each demand point is then assigned to the closest facility, incurring a service cost equal to the distance to its assigned facility. The objective is to minimize the sum of facility costs and the sum of the service costs for the demand points \cite{charikar1999improved}. In our application, where the incoming road users need to form a group, the group center can be seen as the facility, and all road users are customers. However, this series of problems is NP-hard, so the best hope is to use a algorithm with provable approximation of the best solution.

Our algorithm is based on the framework proposed by [], which clusters dynamic and consistent points with a sliding window. The framework is suitable for points other than trajectories. Moveover, it continuously takes single point each time regardless of the restriction in time period. Therefore, the framework is modified to adaptive to our application (see Alorithm 1).

The algorithm works as follows: h points are taken to calculate several solutions with repeated Meyerson algorithm[]. The result with minimum cost Θ becomes the initial coarse siolution. Then, the upcoming data point is taken one by one until the time interval delat\_t between two data points reaches the waiting threshold w (recompute). When the interval not exceed w, a new point is taken, the transport cost from new data point to all current centers are calculated. If the minimum distance d is larger than the facility construction cost f, a new center is built at new points location(update), otherwise the new point will be assigned to its closet centers. The update will continue until the update interval reaches the threshold of update θ/4αf (recompute again).

The pseudo code of current algorithm is shown in Algorithm 1.

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| --- |
| **Algorithm 1**: Dynamic clustering in shared spaces |
| **Input:** A set of data points *X* , distance metrics *ODsimilarity(o1,o2,d1,d2)*  **Output:** A set of centers *F*, an assignment *B* of point to centers  **Initialize:** coarse solution *MeyersonManyTimes( first h number of data points,n )* |
| **while** *X* is not empty **do**  *Δt* ← max time interval of first h items in *X*  **if***Δt > w* **then**  remove first item from *X* until max time interval < *Δt*  recompute centers with removed items by *MeyersonManyTimes*  // recompute because of over waiting time  **else**  take the first *h* items  **if** current time - last recompute > θ/4αf **then**  recompute by *MeyersonManyTimes*  // recompute because of cost criteria  **else**  **if** min(*ODsimilarity*) *< f* **then**  **break**  // too close to open a new facil  **else**  add the *h* item of *X* to *F*  // update  **end**  remove first item from *X*  **end**  **end**  **end** |
| Procedure *MeyersonManyTimes(first h number of data points,n)*  repeat Meyerson *n* times  initial centers ← solutions with lowerest cost θ  Procedure *ODsimilarity(o1,o2,d1,d2)*  *|o1-o2| + |d1-d2|* |

1. Result
   1. Spacing

You must use single line spacing. However, when typing complicated mathematical text it is important to increase the space between the text lines in order to prevent sub- and superscript fonts overlapping one another and making your printed matter unreadable.

Between the end of one section and the title of the next one, two full spaces must be added. The only exception is when the title of a section is at the beginning of a column.

* 1. Fonts

All text should be Times New Roman. Font sizes and styles are defined in the respective paragraph styles.

Section, subsection and subsection titles should use their own styles, “Section 1”, “Section 2” and “Section 3”, respectively. It should be pointed that text immediately after a section title should use “NormalPostSection” style, while the rest of the text should use “Normal” style. As you can see, there is some bleeding or indentation at the beginning of each paragraph in the normal text that is absent in the paragraphs that follow a section title.

* 1. Equations

Equations have to be numbered individually, using this number between parentheses to cross-reference them. They have to appear, if possibly, in one column.



In case an extremely long equation cannot be rendered in one column without affecting its readability, a text box can be used to span it across both columns. **Make sure you use one box per formula.**

Nevertheless, try to avoid this rendering as it might be confusing to readers. See the difference between (1) and (2).

Table 1: Example of table with title above.

Source: LyX's detailed Figure, Table, Floats, Notes, Boxes and External Material manual.

Figure 1: Example of figure, with title above the image.



Source: Perry-Castañeda Library Map Collection, University of Texas.

* 1. Tables

Tables can appear in one column, as in Table 1, or spanned across both of them, as in Table 2, using a text box. **Remember to use one text box per table**.

Nevertheless, try to make tables that fit in one column as frequently as possible. See the difference between Tables 1 and 2.

Horizontal lines for separation between rows must be used, while no vertical lines for separation between columns are needed.

Titles or captions have to be placed above the tables, preceded by “Table”, the number that identifies the table and a colon. Titles or captions that use less than one line must be centered, while those that use more than one line must be justified.

Sources for the tables have to appear underneath them, justified and preceded by “Source:”.

* 1. Figures

Figures can appear in one column, as in Figure 1, or spanned across both columns, as in Figure 2, using a text box. **Remember to use one text box per table.**

It is important that you use high resolution images to keep the highest quality across the whole editing process. Images should have at least 300 DPI in the size they are going to be rendered in the camera ready version of the paper. No separate files for the figures are needed.

Titles or captions have to appear above the image, preceded by “Figure”, the number that identifies the figure and a colon. Titles are centered when they use less than one line and justified in other case. Sources for the images have to appear underneath them, justified and preceded by “Source:”.

1. References

References have to be cited according to the Harvard citation style (Imperial College Library, 2012).

References have to appear in a separated, unnumbered section called “References”. The title “References” has to be typed using the “ReferencesTit” style. References have to be sorted alphabetically. References are typeset using the “References” style.

You can use the following as examples to format the main types of references (based on the “Plain” BibTeX style):

* Journals: Walter Crosby Eells. A mistaken conception of the center of population. *Journal of the American Statistical Association*, 25(169):33-40, 1930.
* Proceedings: Shan-Huo Chen and Chien-Chung Wang. Fuzzy distance using fuzzy absolute value. In *Proceedings of the Eighth International Conference on Machine Learning and Cybernetics*, Baoding, 2009.
* Book chapters: J. Darzentas. On fuzzy location model. In J. Kacprzyk and S. A. Orlovski, editors, *Optimization Models Using Fuzzy Sets and Possibility Theory*, pages 328--341. D. Reidel, Dordrecht, 1987.
* Books: Andy Ruina and Rudra Pratap. *Introduction to statics and dynamics*. Oxford University Press, Oxford, 2011.
* Edited and collective books: A. Ravi Ravindran, editor. *Operations research and management science handbook*. CRC Press, Boca Raton, 2008.

For aesthetic reasons, try to balance columns in the last page of the paper.

Figure 2: Example of figure, with title above the image.



Source: Perry-Castañeda Library Map Collection, University of Texas.

Table 2: Example of table with title above

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| --- | --- | --- | --- |
| System | Chip 1 | Chip2 | |
| Detector thickness in µm | 300 | 300 | 700 |
| Edge angle in ° | 3.55 | 2.71 | 7.99 |
| Spatial resolution in µm | 4.26 | 10.17 | 10.56 |
| MTF at fmax | 0.53 | 0.37 | 0.39 |
| LSF-spatial resolution in µm | 129.7 | 52.75 | 50.78 |
| In % of pixel size | 76.3 | 95.9 | 92.3 |

Source: LyX's detailed Figure, Table, Floats, Notes, Boxes and External Material manual.

References

Chen, S.-H. and Wang, C.-C. (2009) Fuzzy distance using fuzzy absolute value. In: *Proceedings of the Eighth International Conference on Machine Learning and Cybernetics*, Baoding, 2009.

Darzentas, J. (1987) On fuzzy location model. In: Kacprzyk, J. & Orlovski, S.A. (eds.) *Optimization Models Using Fuzzy Sets and Possibility Theory.* Dordrecht, D. Reidel , pp. 328-341.

Eells. W. C. (1930) A mistaken conception of the center of population. *Journal of the American Statistical Association*, 25(169), 33-40.

Imperial College Library (2012) *Citing & Referencing: Harvard Style*. [Online] Available from: <http://www.otago.ac.nz/library/pdf/Harvard_referencing.pdf> [Accessed 10th November 2016].

Ravi Ravindran, A. (ed.) (2008) *Operations research and management science handbook.* Boca Raton, CRC Press.