

Review Comments

Reviewer 1

General comment: This study estimates the density of passengers waiting to board on urban railway platforms. The logic of this manuscript is clear and the result is reasonable. The following comments may help to improve this manuscript.

Answer to General comment: Thank you very much for the comments. We tried to address them as best as possible.

1. The result of the experiment in this study should be introduced and summarized in the abstract.

Answer to Comment 1: Thank you for this suggestion. A new abstract was included to highlight the results and method used:

“The platform-train interface (PTI) is considered a complex space where most interactions occur between passengers boarding and alighting. These interactions are most critical under crowded conditions, affecting the experience of travelling and therefore the quality of life. The problem is that urban railway operators do not know what the density is in real time at the PTI, and therefore it is not possible to obtain a measure of the personal space of passengers boarding and alighting the train. To address this problem, a new method is developed to estimate the density of passengers on urban railway platforms by means of laboratory experiments. In those experiments, the use of computer vision is attractive, through training of neural networks and image processing. The experiments considered a mock-up of a train carriage and its adjacent platform. In the boarding process, the results showed that the density using Voronoi polygons reached up to 300% difference compared to the average values of density using Fruin’s Level of Service. However, in the case of alighting, that difference reached about 142% due to the space available for wheelchair users who needed assistance. These results would help practitioners to know where passengers are located at the PTI and therefore which part of the platform is more congested to implement crowd management measures in real time. Further studies need to include other types of passengers and different situations in existing stations.”

We also included some changes in the title of the paper to better highlight what we studied. The new title is: “Experimental method to estimate the density of passengers boarding and alighting on urban railway platforms”.

2. The authors said that the new method is proposed to estimate the density of passengers waiting to board. However, the difference between the proposed method and other methods is not compared. If possible, the result of using the proposed method and other methods should be compared to show the effectiveness of the proposed method.

Answer to Comment 2: Thank you for this remark. We added the following tables to compare the results between the proposed method and other methods such as the average values of density using Fruin’s Level of Service. We included the following tables and paragraphs:

The results for each polygon are reported in Table 4, in which the difference between the density using Voronoi polygons and the Fruin’s Level of Service reached up to +301.6%. It is also important to notice that the variability of the density also presented a reduction in a range between 45.1% and 16.6%. This is caused because the Voronoi polygons represented in a more detailed manner the interaction between passengers. In other words, the Voronoi polygons represented the personal space occupied in the boarding process, while the average values of density using Fruin’s Level of Service is focused on the number of passengers on the whole platform. Therefore, if the Voronoi polygons are used it is possible to identify where passengers are located and which part of the

platform is more congested, generating the data to support the need of re-designing the platform train interface which should have an improved LOS (Level of Service). In fact, the LOS is applied to the Voronoi polygons, in which Table 4 shows that each boarding passenger represented a different LOS, reaching a value from A to F, depending on the density of each polygon which is affected by the number of passengers boarding on the platform.

Table 4. Density estimation using Voronoi polygons compared to the average values of density using Fruin's Level of Service considering boarding passengers on the platform.

Polygon number	Voronoi's Occupied Space [m ² /passenger]	Voronoi's Density [passenger/m ²] and Level of Service (LOS)	Fruin's Density [passenger/m ²] and Level of Service (LOS)	Density difference between Voronoi and Fruin method
1	0.166	6.024 (LOS F)	1.50 (LOS C)	+301.6%
2	0.303	3.300 (LOS D)	1.50 (LOS C)	+120%
3	0.527	1.897 (LOS D)	1.50 (LOS C)	+26.5%
4	0.392	2.551 (LOS D)	1.50 (LOS C)	+70%
5	0.800	1.250 (LOS C)	1.50 (LOS C)	-16.6%
6	1.057	0.946 (LOS B)	1.50 (LOS C)	-36.9%
7	0.420	2.380 (LOS D)	1.50 (LOS C)	+58.6%
8	1.115	0.896 (LOS B)	1.50 (LOS C)	-40.2%
9	1.215	0.823 (LOS A)	1.50 (LOS C)	-45.1%

Similarly, in Figure 7 three alighting passengers were detected on the platform, and therefore the average density reached is equal to 0.50 passengers/m² (2.0 m²/passenger). This average density (or available space per passenger) is different from the results obtained when using the Voronoi polygons. Table 5 shows the difference between the average density using Fruin's LOS and the Voronoi polygons, reaching a difference up to +142.6%. It is important to mention that the variation also presented a negative variation of -48.8% in the case of polygon 3 which is represented by the wheelchair passenger. It can be also noticed that polygon 3 corresponding to the passenger in a wheelchair needed assistance from another passenger (polygon 2). This mean that both passengers (polygons 2 and 3) will need more space to move than a single passenger without reduced mobility.

Table 5. Density estimation using Voronoi polygons compared to the average values of density using Fruin's Level of Service considering alighting passengers on the platform.

Polygon number	Voronoi's Occupied Space [m ² /passenger]	Voronoi's Density [passenger/m ²] and Level of	Fruin's Density [passenger/m ²] and Level of	Density difference between Voronoi and
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		Service (LOS)	Service (LOS)	Fruin method
1	0.824	1.213 (LOS C)	0.50 (LOS A)	+142.6%
2	1.278	0.782 (LOS A)	0.50 (LOS A)	+56.4%
3	3.897	0.256 (LOS A)	0.50 (LOS A)	-48.8%

3. Some detailed suggestions for controlling passengers on the platform should be introduced according to the result, which can enhance the practicality of this manuscript.

Answer to Comment 3: Thank you for this suggestion. We added the following paragraph in section 4: “As a consequence, crowd management measures should be implemented, in which passengers could have some preferential space on the platform. For instance, some authors [41,55] have been presented the use of waiting areas to facilitate the boarding and alighting process, which will be expanded in future experiments (see Figure 9).”



Figure 9. Example of crowd management measures to reduce the interaction on the platform by the generation of waiting areas to let passengers get before getting on the carriage.

In addition, the following sentence is adjusted in the conclusions: “The implementation of control measures can be used by transport planners to provide certainty to passengers that the train will not stay at the platform for additional time when a crowded situation is reached. In addition, it can be used to identify when the platform needs to be re-designed to reduce the interaction between passengers boarding and alighting.”.

4. The experiment is carried out in this study. However, I am concerned that the experiment cannot reflect passengers’ real actions on the platform. How can you make the experiment close to the real situation?

Answer to Comment 4: Thank you for this comment. In the literature review it is mentioned the following sentence: "These authors conclude that the experimentation allows testing different designs of the vehicle-platform interface based on existing stations, where a single variable changes while the rest of the variables (for example, light, sound, information, physical design, etc.) remains the same. In this way, laboratory experimentation makes it possible to control the variables and use computer vision tools for the pedestrian study."

In addition, the following sentence was added in the conclusions: "With respect to the experiments, the approach used presented an ideal opportunity to test "what if" scenarios, in which the boarding and alighting process is represented considering a mock-up of the train carriage and its adjacent platform. The objective is to represent the variation of one variable "X" considering the rest of the variables without change. Therefore, the effect of the "X" variable on the passenger's space or density at the platform train interface could be analyzed. In the case of the boarding process, the Voronoi polygons represented up to 300% variation compared to the average values of density using the Fruin's Level of Service. In the case of the alighting process, the variation reached up to 142% of difference between both methods, considering the need of wheelchair users. As a next step, the density on existing stations will be considered using the Voronoi polygons to compare them with the Fruin's Level of Service."

5. Finally, there are some grammar mistakes, such as "These interactions are caused because off the high level of demand at the PTI ".

Answer to Comment 5: We appreciate the Reviewer's comment. We checked the spelling and grammar mistakes.

In addition, we changed the word from "diagram" to "polygon" to better explain what we referred by Voronoi polygons.

In the case of same tables (e.g. Table 3) we included the units.

We also, included the definition of area of interest as the space of the platform defined by an area of 6 m² (3 m long by 2 m wide). And we incorporated the definition of acronyms such as FOV (Field of View).

The improved version of the paper (especially in terms of grammar mistakes) will also help to better understand the method and results.