

# The deployment of a generic user-oriented participatory sensing framework in a real-world context

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## Abstract

Participatory sensing is a promising approach to collect multi-modal information in a large scale. However, it completely relies on the motivation of the participants, whose behaviors are unpredictable. In this work, we briefly introduce the Citizense framework, then detail the deployment in which Citizense was used by a large number of participants with various backgrounds. This deployment provides valuable insights into the participants' behaviors and ways to attract more interactions from these users.

*Keywords:* Participatory sensing, usability, smart city, monetary incentive

## 1 Introduction

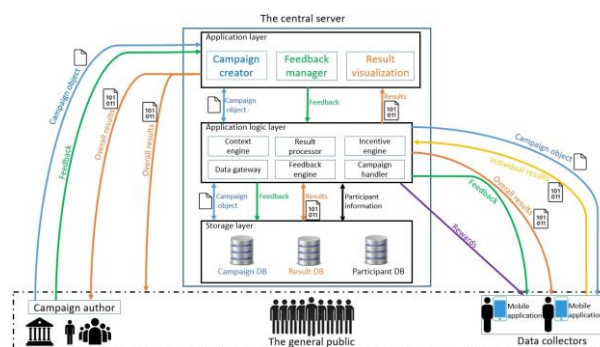
Participatory sensing has been proven to be an efficient method to collect multi-modal data with high spatial and temporal resolution. This method has seen a plethora of applications, for example noise measurement (Maisonneuve, 2009), environmental monitoring (Kaufman, 2017), city infrastructure monitoring and incident reporting (Walravens, 2013). However, this method entirely relies on the willingness of data collectors to contribute their observations, opinions as well as raw sensory data. Furthermore, this data collection process might incur expenses such as the extra consumption of battery, mobile data and raise privacy and security concerns. Therefore, it is essential to introduce a rewarding system that incentivizes the active participation of data collectors, apart from a technically good and usable participatory sensing application. In this way, the efforts spent by data collectors to correctly and timely contribute the data is fairly compensated.

## 2 The architecture of the framework

Citizense is a generic user-oriented participatory sensing framework, aiming to ease the process of creating and managing participatory sensing campaigns. The framework consists of four main components (Figure 1): the campaign object, the campaign manager, the campaign server and the mobile client application (app). In this framework, the campaign object is the central entity, it dictates how a participatory sensing campaign is executed by the participants and processed by the central Citizense platform. A campaign object represents a sensing process (a campaign); the object contains the types of data that will be collected, the actual tasks that the data collectors will perform (in the forms of atomic sensing tasks), the context in which the campaign is executed, among other parameters. This campaign object is

created in the campaign manager, stored in the campaign server and executed in the participants' mobile devices. Two main actors interact with the Citizense framework; the campaign authors create the campaign object by the campaign manager and the data collectors execute the campaign in their mobile devices. At the time of writing, the framework support 13 different types of atomic sensing tasks, grouped into three groups: sensory input, multimedia input and human input.

Figure 1: The architecture of Citizense framework, from the user's point of view



## 3 The real-world deployment of the Citizense framework

The Citizense framework has been deployed in the campus of Castellón, in Spain as we have access to a large number of students, staffs and professors, who have different backgrounds. The campus itself acts as a model of a Smart city, with the participants acting as citizens being governed by

the authority, which are the university and the local authority of Castellón.

Throughout the recruitment process, 359 participants joined the deployment, of which 230 were data collectors and the rest acted as campaign authors. Using the web-based campaign manager, the campaign authors created 34 campaigns on a variety of topics that are related to common issues in the city. On the other side, we launched 10 campaigns on specific topics that are relevant to the participants; 7 of these campaigns (of different time duration) are applied with different incentive monetary mechanisms. Data collectors are randomly assigned with incentive mechanisms and informed about the details of the assigned mechanism before executing the campaigns. Specifically, mechanism 1 gives gifts to some lucky data collectors among those who completed a specific campaign. Mechanism 2 gives a fixed amount of cash as soon as data collectors finished the data collection process. Mechanism 3 divides a pre-determined budget to the set of data collectors who joined a specific campaign. Mechanism 4 is a control mechanism, which does not give data collectors any rewards. While mechanism 2 delivers rewards immediately, mechanisms 1 and 3 delivers the rewards at the end of the campaign to which these mechanisms are applied. The setting of the deployment allows the data collectors to be exposed to different monetary incentive mechanisms at the same time while they are executing realistic participatory sensing campaigns.

## 4 The results

### 4.1 The participation of the campaign authors

The campaign authors managed to create 34 campaigns on wide range of campus- and city-related topics, such as public transportation, city infrastructure, cultural promotion, social vulnerability, entertainment venues, city infrastructure and food consumption. Apart from this variety of topics, the average complexity of the campaigns also reached adequate level. Although it is the first time the campaign authors interacted with the Citizense platform, they managed to use all the framework's features to customize their campaigns. For example, these campaigns included conditional transitions between the atomic sensing tasks, location constraints are added to the campaigns to limit the scope of the campaigns to certain areas. As a result, based on the characteristics of the campaigns, it can be concluded that Citizense platform is easy to use and no additional technical assistance is required.

### 4.2 The participation of the data collectors

For each of the 7 campaigns applied with incentives, it is replicated into four functionally identical versions, each version is applied with the three aforementioned monetary incentive mechanisms and the control mechanism (no rewards are provided). Each version is monitored using the open count (the number of times this campaign version is opened) and the submission count (the number of times this campaign version is submitted). Subsequently, the attraction index (the ratio between number of submission and number of open of a

campaign) shows how the details of an incentive mechanism drive people to complete a campaign.

Figure 2: The open count of the campaigns with incentives

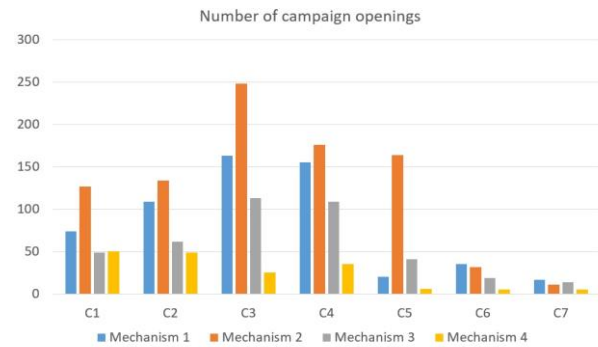


Figure 3: The submission count of the campaigns with incentives

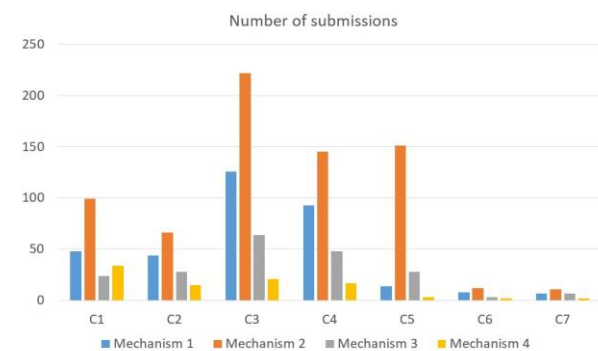
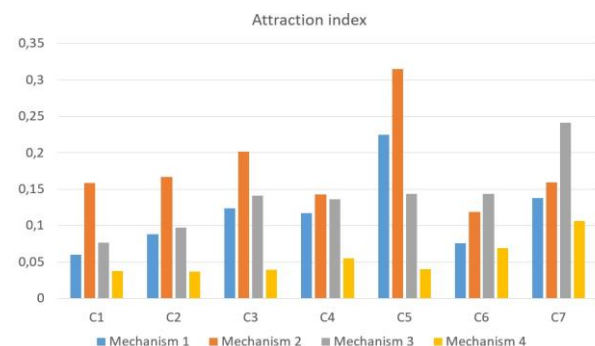


Figure 4: The attraction indexes of the campaigns



From the Figure 2 and 3, it is clear that monetary incentives motivate data collectors; the versions applied with mechanism 1, 2 and 3 resulted in much larger number of interactions (open, submission) from the data collectors. Statistical tests (Chi-square, Mann-Whitney U and Kruskal-Wallis) on the number of open and submission confirm that there are significant differences between the data collectors'

preferences on different mechanisms. Furthermore, there is an order among the mechanisms: mechanism 2 performs the best, followed by mechanism 1 and mechanism 3 (similar effectiveness) while mechanism 4 always has the worst performance; this order is supported by the average number of open and submission per incentive mechanism. The data collectors seem to prefer concrete and predictable rewards for their data contribution (mechanism 2) rather than to wait until the end of the campaigns to earn their rewards (mechanism 3) or participate in a lottery to win a valuable gift (mechanism 1).

## 5 Conclusions

In this paper, we present the deployment of the Citizense framework in a real-world context. The framework was met with large interest from the participants, acting as campaign authors and data collectors. While campaign authors enthusiastically took the opportunity to create sensing addressing relevant topics in their city, the data collector reacted positively to the monetary incentives.

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