Incentive Mechanisms to Foster Crowdsensing: Lessons from the Literature for a Collaborative Map Project

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Resumo

A systematic review of the literature (SLR) was performed to assess how incentive mechanisms and rewards affect the way users contribute to crowdsensing systems. Several criteria were used to define the SLR corpus, starting from more than 3900 academic paper entries, obtained from a search for the terms "motivation" and "crowdsensing" in a comprehensive set of databases including academic papers. After applying several exclusion criteria filters, the corpus of the SLR comprised 65 papers, in which we identified eighteen incentive mechanisms that were analyzed considering the application areas of the proposed systems. While monetary reward seems to be the most prevalent form of incentive, it is primarily associated with microtasks, which do not require a lot of effort or commitment from those involved. Gamification was the more broadly used incentive mechanism, having been reported by authors concerned with crowdsensing activities ranging from accessibility and urban mobility to citizen science and health. Remarkably, altruism and other social factors seem to play a modest role as an incentive mechanism for crowdsensing, if the academic literature reflects what is happening in the field.

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Abstract

A systematic review of the literature (SLR) was performed to assess how incentive mechanisms and rewards affect the way users contribute to crowdsensing systems. Several criteria were used to define the SLR *corpus*, starting from more than 3900 academic paper entries, obtained from a search for the terms "motivation" and "crowdsensing" in a comprehensive set of databases including academic papers. After applying several exclusion criteria filters, the *corpus* of the SLR comprised 65 papers, in which we identified eighteen incentive mechanisms that were analyzed considering the application areas of the proposed systems. While monetary reward seems to be the most prevalent form of incentive, it is primarily associated with microtasks, which do not require a lot of effort or commitment from those involved. Gamification was the more broadly used incentive mechanism, having been reported by authors concerned with crowdsensing activities ranging from accessibility and urban mobility to citizen science and health. Remarkably, altruism and other social factors seem to play a modest role as an incentive mechanism for crowdsensing, if the academic literature reflects what is happening in the field.

Keywords

Rewards mechanisms, incentive mechanisms, crowdsensing, participatory sensing; collective intelligence, accessible maps.

INTRODUCTION

When using online map systems, updated information can make a difference between taking an efficient route or not even being able to arrive at the planned destination. Imagine a road map system in which street direction information has not been fixed to reflect changes performed to the environment it represents, or a pedestrian route suggesting system that does not bring information on obstacles or construction work that momentarily make side-walks inaccessible. If any of that happens, the system does not provide a good service to users and is, therefore, not perceived as valuable. Any problem users have when trying to use a system and being exposed to unreliable data may cause them to stop using it (Salles *et al.*, 2006). Engelbert and Graeml (2015) remind us that for a new technology to achieve its intents, it needs to be adopted and used by those it was designed for, which will only happen if they perceive it as being useful and easy to use (Davis, 1985).

The collective intelligence (CI) of users is an efficient way of gathering information, when users can tag online items or provide feedback, which may be very useful to update map systems. This is what happens, for example, in OpenStreetMap and other pedestrian navigation systems (Budhathoki and Haythornthwaite, 2013; Prandi *et al*., 2015), in which users become providers of updated information to ensure the quality of the provided service.

A widely used term in the literature for gathering and updating information with the help of users and their mobile devices is crowdsensing, as noted by Ganti *et al*. (2011). It is a technique by means of which a group of individuals collectively shares data and extracts information to measure, map, analyze or estimate variables of common interest (Peng *et al*., 2015). As observed by Sadovykh and Sundaram (2017), a community that communicates and shares knowledge quickly has an advantage, when compared to others that do not collaborate.

The user's participation, working as a "sensor", can be fundamental to keeping maps up to date, contributing to the success of an application. According to Zhang *et al.* (2016), the power of detection/sensing systems depends heavily on the number of participants willing to contribute. However, users may be reluctant to participate and share their sensing capabilities, due to a variety of reasons. Collaborating may generate costs (communication, processing and energy) and risks to user's privacy (Zhang *et al*., 2016), for example. Therefore, it is reasonable for people not to contribute, unless they are provided with the appropriate incentives.

Different authors suggest the use of different forms of incentives to encourage participation in ventures that depend on aggregate efforts performed by multiple people. Malone *et al*. (2010) mention love, glory or money, while for Chamberlain *et al*. (2009) incentives are personal, social or financial. Considering that there is still a lot of discussion about the issue, without an agreement on the types of possible incentives or even the terminology to refer to them, we decided to carry out a systematic literature review (SLR) to better understand how far researchers have already gone in addressing the matter. We plan to answer the following research question by means of this study: what are the motivations and reward mechanisms that stimulate users to collaborate with crowdsensing systems' initiatives?

We believe the main contribution of this paper is to identify and organize user motivation mechanisms to obtain engagement of users/participants to mobile crowdsensing projects, based on the extant literature. We are particularly interested in assessing their applicability to support the construction and updating of accessible map systems, which is something we intend to focus on, in the near future.

The paper is organized as follows: the next two sections give an overview of participatory sensing (crowdsensing) and the motivation for collective intelligence projects, in general. After that, we explain the methodological procedures that were adopted in the systematic literature review. The obtained results are presented and discussed, then, allowing us to aggregate and systematize the knowledge that was captured from the analysis of the *corpus* of the SLR. Finally, we conclude this paper, highlighting the main findings of the study and pointing out to the next steps in our research.

MOBILE CROWDSENSING (MCS)

Mobile crowdsourcing (MCS) is a production model that uses CI to solve problems, create content or seek for innovation, and involves gathering large quantities of information to use in different contexts (Calle-Jimenez and Luján-Mora, 2015). With the omnipresence of mobile devices in a mostly connected world, MCS has become a powerful tool to feed participatory systems, using sensor data and the Internet, on a social scale. MCS takes advantage of devices that "follow" users, wherever they go (smartphones go in their pockets), to acquire important localized knowledge that may be essential to keep systems updated and relevant (Ganti *et al.*, 2011).

Silva *et al.* (2014) argue that MCS systems allow people to share useful data about the context, at any time, becoming potential detection/sensing sources on a global scale. Due to the extensive applicability of mobile crowdsensing, a broad scope of uses has been conceived to explore the power of sensing by the crowds (Xu *et al*., 2015). Among such, we can highlight: *BikeNet* (Eisenman *et al*., 2009), which features healthcare, mapping the experience of a bicycle rider while on a ride, *Haze Watch* (Sivaraman *et al*., 2013), for monitoring pollution, *NoiseTube* (Maisonneuve *et al*., 2009), for the generation of noise maps for cities, *mPASS* (Prandi *et al*., 2014), to collect data on urban and architectural accessibility, and *MySidewalk* ™

(Erraguntla *et al.*, 2017), a platform to collect and maintain information on the location, condition, connectedness, and gaps in the sidewalk network in a city.

Depending on the type of application, and the resources available to the used device, an MCS can be classified as "participatory" or "opportunistic" (Ganti *et al.*, 2011). It is "participatory" when the data generated by users results from individual mobile devices and users need to know the context of the application to perform data collection, on a volitional basis. The "opportunistic" approach takes advantage of other online social interactions, for example, check-ins performed in a social network (Silva *et al.*, 2014). In that case, users are not necessarily aware of the real context of the application.

MOTIVATION FOR COLLECTIVE INTELLIGENCE

Issues related to human motivation are studied in different fields, such as psychology, philosophy and even economics (Frey and Jegen, 2001; Ryan, 2012). Woolley *et al.* (2010) emphasize that human motivation cannot be overlooked, since it is a crucial factor to obtain performance from a group of people.

Malone *et al.* (2010) discuss what they consider to be the genes of CI and emphasize the motivations that lead individuals to contribute to a project, stressing that love and glory, rather than money, can reduce costs, but glory and money can influence the direction and speed of a group's effort. Chandler and Kapelner (2013) point out that, the more meaningful a work is, the greater chances are that participants become interested in contributing to it. In addition, the more significant the work is perceived to be, the lower the required monetary reward, according to these authors.

For Zhao and Zhu (2014), motivation factors and personal characteristics (age, gender, social condition) may affect the level of participation in crowdsensing, being the existence of a monetary reward a motivator that directly correlates to participation, considering the required time and the complexity of the required task. Social incentives may be used to reward users by improving their sense of relevance among peers (Chamberlain *et al.*, 2012).

Coleman *et al*. (2009) argue that in systems where users generate voluntary geographical information (VGI), altruism, intellectual stimulation and social rewards can positively influence the users to contribute. However, they warn that negative factors could also play a role and that not all contributors may be interested in providing accurate, useful and truthful information. "Vandals" may wish to generate skepticism or confusion by replacing real information with meaningless content, for example.

Thus, before choosing an appropriate incentive mechanism, it is necessary to evaluate the application context and the target audience for the system (Katmada *et al.*, 2016). There is a strong relationship between attitude and intention to contribute, that is, when one perceives a behavior as favorable, there is a higher chance that s/he behaves accordingly (Ajzen, 1991).

METHODOLOGICAL PROCEDURES

A search was made in the following digital libraries: AIS Electronic Library, IEEE Xplore Digital Library, ACM Digital Library, Periodicos Capes and Google Scholar to obtain the *corpus* for the intended SLR. The first three databases (AIS Electronic Library, IEEE Xplore Digital Library, and ACM Digital Library) were selected to provide access to papers published in the proceedings of conferences, although they also include papers published in journals sponsored by those academic associations. The two last ones (Periodicos Capes and Google

Scholar) are very comprehensive databases, for proceeding and journal papers. Google Scholar, many times, does not provide full access to the papers it lists among its search results, but it has already been acknowledged to be a very effective mechanism to depict papers to be includes in SLRs (Noruzi, 2005; Caregnato, 2011; Gehanno, Rollin and Darmoni, 2013), providing more comprehensive results than searches in any other academic database. The drawback of using Google Scholar is that, many times, access to the full content of papers may rely on different sources, later.

The search followed the SLR protocol proposed by Kitchenham (2004). It started with a search for the expressions "motivation" and "crowdsensing" or “participatory sensing”, appearing in any part of the searched papers. For Google Scholar, particularly, the title and abstract of all returned entries were read up to when two consecutive search pages (20 entries) did not result in any additional paper being selected for inclusion in the *corpus*, for not contain papers with the expressions "crowdsensing" (or equivalent) and "motivation" (or equivalent) in their title or abstract. This preliminary filtering criteria was used, for Google Scholar, because its search engine returns very good results in the first few result pages, but quality of the results deteriorates after that. By using this expedient, 1583 potentially relevant entries were obtained.

In addition to those 1583 entries from Google Scholar, 185 entries were preselected from AIS Electronic Library, 332 from IEEE Xplore Digital Library, 738 from ACM Digital Library, and 1142 from Periodicos Capes, totaling 3980 papers to be further processed. After 588 duplicated papers were discarded, 3392 papers remained.

As the next step, the titles and abstracts of all papers still in consideration were read to check for fit (except papers from Google Scholar, for which such procedure was carried out in a previous step). The title or the abstract was expected to refer to users' motivation to contribute to IC systems based on crowdsensing. 3257 articles were discarded because their title and abstract pointed in different directions, showing that crowdsensing and motivation were not central issues discussed in the papers. The remaining 135 papers were thoroughly read to make sure they were relevant, 65 of which being kept in the *corpus* of the study. Figure 1 shows the filtering process used to select papers to be included in the SLR, in a schematic way.

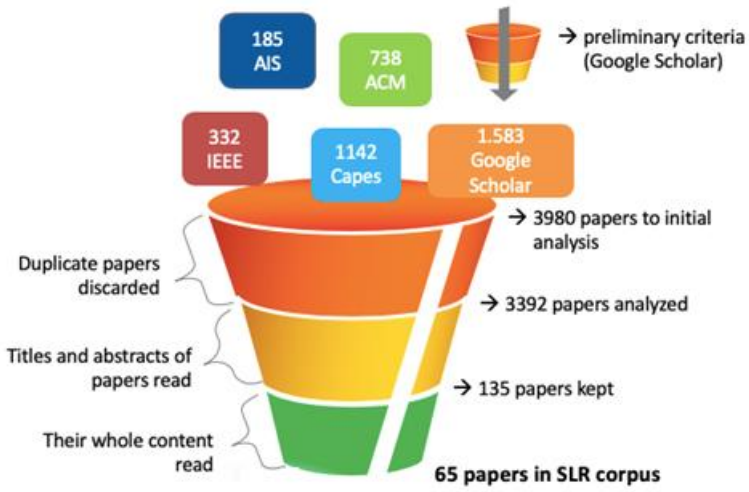

Figure 1. Criteria for inclusion of papers in the corpus of the systematic literature review

Quality assessment of the papers was not part of the scope of the study, which means that all papers that were concerned with the topic of interest were included in the review, after having survived the filtering criteria presented in Figure 1.

RESULTS

The 65 papers that met all criteria to be included in the *corpus* of the SLR are presented in the appendix. The timeline distribution of published papers in shown in Figure 2. There has been an increase in the number of publications about motivation for crowdsensing over the years, evidencing the growing interest in the topic.

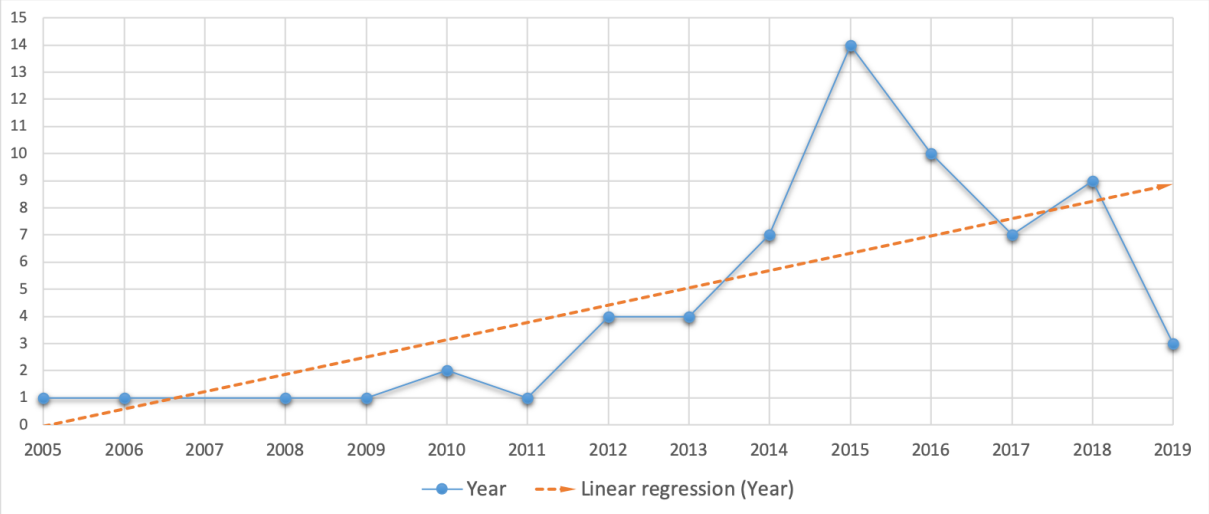

Figure 2. Timeline distribution of papers about motivation in crowdsensing

Note: Selection of the SLR corpus happened in May 2019, so data for that year is incomplete.

Several mechanisms to motivate and encourage users to contribute to crowdsensing systems have been identified. We tried to group them when it was clear the authors were talking about the same thing but preferred to keep them apart when there seemed to be even subtleties that made authors to try and differentiate them. We acknowledge that further aggregation is surely possible, but the intent was not to get to a small set of motivation mechanisms, but rather provide a comprehensive view of the different mechanisms as proposed in the literature. Each of these mechanisms is briefly explained, next:

- **Gamification:** developing a game-design-based incentive process, which intends to recruit users to solve problems, by including game elements such as scoring, rewards and difficulty levels to motivate users to carry out the expected activities (Brito *et al.*, 2015).
- **Monetary reward:** providing cash or a prize payment for sensing tasks (Ogie, 2016).
- **Points:** giving points that can be exchanged for services or products to users who perform sensing tasks (Hoh *et al.*, 2012; Galinina *et al.*, 2018).
- **Social incentive:** encouraging one's friends to also contribute with sensing tasks, taking advantage of the social bonds among participants to increase the number of collaborators (Yang *et al.*, 2017).
- **Hall of fame:** spotlighting users with the highest scores in the system (Rafelsberger and Scharl, 2009), exploring the glory gene, as proposed by Malone *et al.* (2010).
- **Semantic crowdsourcing:** creating an ontology based on schemas.org to standardize annotation of data. This way, several systems can share data among themselves, increasing coverage (Mazayev *et al.*, 2016).

- **Urban mobility:** suggesting tasks that do not take participants out of their way while performing them, as they move from one place to another, guaranteeing a balanced data coverage for the sensing program (Ji *et al.*, 2016).
- **Altruism:** relying on love of one's neighbor, or disinterested concern, philanthropy, self-denial or community sense (Basiouka and Potsiou, 2014). It explores the love gene, as proposed by Malone *et al.* (2010).
- **Sense of utility / value added:** leading users to understand that the goal of the system can benefit themselves and other people, improving health or social inclusion. This may increase the likelihood of participation in performing tasks, compared to systems perceived by users as mere "objects of interest" (Mekler *et al.*, 2013).
- **Social factors:** considering socioeconomic issues, privacy, level of effort, commercial interest or public good. The higher the perceived social value of an application, the greater its ability to explore altruism, reducing the need for financial compensation for tasks to be performed (Ogie, 2016).
- **Fun:** making users to perceive the collecting data task as being fun (Väätäjä, 2012).
- ***Quid-pro-quo:*** this Latin expression means "tit for tat", i.e., offering something in exchange for the collected data (Tomasic *et al.*, 2014).
- **Storytelling*:*** leading the user to tell stories or make reviews, sharing them with other users (Tobien *et al.*, 2016).
- **Psychological empowerment:** empowering the user and making him/her feel important. Commitment to the achievement of one's relevant personal goals strengthens the activity and, consequently, generates psychological stimulation (Gonçalves *et al.*, 2015).
- **Visual cues:** providing visual cues as part of the communication for the participant to be able to solve a puzzle or guess a meaning. For example, in a map system, displaying photos of locations as one navigates, requesting users to tag and mark the map (Gonçalves *et al.*, 2015).
- **Situation at the place of occurrence:** providing the possibility of visualizing a situation that occurred exactly at a specific place can stimulate the user to contribute with additional annotation. For example, in a map system, one can zoom in to a precise location (Gonçalves *et al.*, 2015; Wei and Anwar, 2017).
- **Social transparency:** using real names and identities (Huang and Fu, 2013).
- **Social facilitation:** comparing one's work with someone else's in his/her group (Huang and Fu, 2013).

The matrix chart in Figure 3 shows the relationship between the incentive mechanisms and the areas in which they were applied, according to the researchers who discussed them in the reviewed papers. As it can be seen, "monetary reward" is widely used for "microtask" activities. These are activities that do not require a lot of effort or commitment from participants. But they may also not provide them with any other perceived benefit that could work as an incentive.

It is interesting to note that the most widely used motivation mechanism, for all types of applications, except participatory journalism and community policing, was "gamification", which stimulates users to collect data using game elements or creating a game, whose real purpose may be hidden in its context. By using "gamification" as an incentive mechanism, the developers of an application may intend to save on "monetary rewards" that would, otherwise, be required by participants to perform the required tasks.

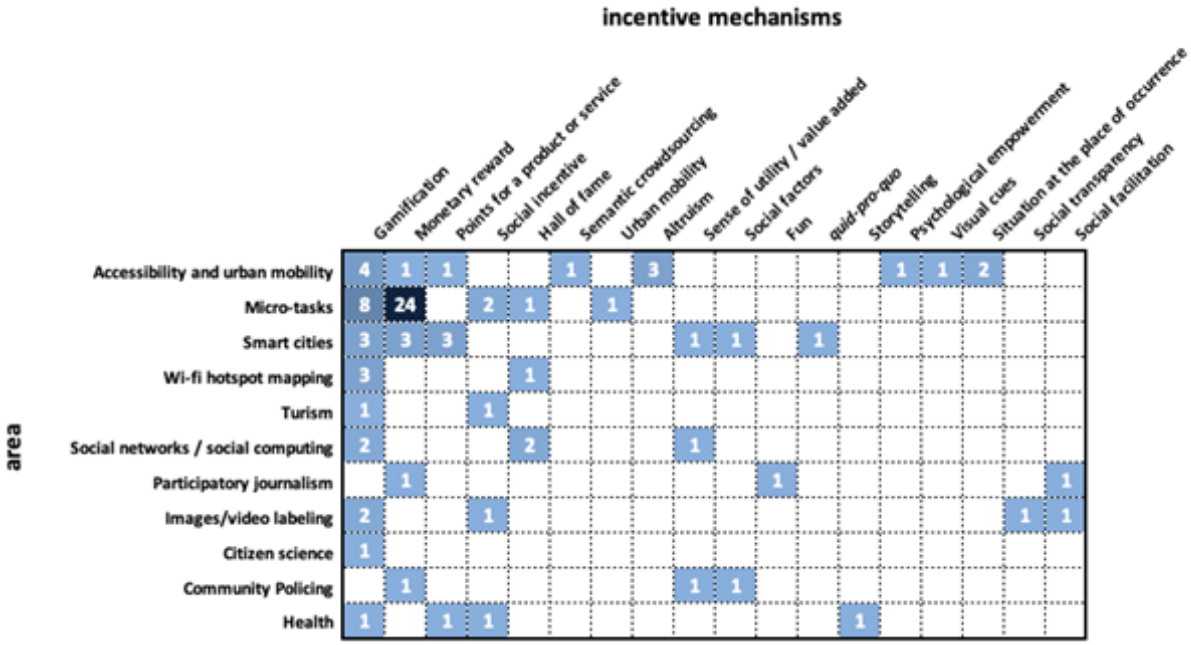

Figure 3. Relationship of incentive mechanisms to the areas of application.

In forty-three papers (66% of the *corpus*), authors assessed the incentive mechanisms that were used to involve users by means of some sort of field research. In twenty-three papers (35%), a computer simulation was performed to assess the proposed incentive mechanisms. Only nine papers included in the SLR (13%) did not mention any form of assessment of the proposed incentive mechanism. On the other hand, in approximately 86% of the analyzed papers, although the authors argue that the described incentive mechanism contributed to increase the number of participants, to reduce the cost of obtaining contribution or to improve the quality of the collected data, no evidence of that was presented.

DISCUSSION

Incentives to engage users in crowdsensing activities are, clearly, a topic of interest in the literature. The main forms of incentives discussed in the reviewed studies are discussed next, focusing on those used in collaborative maps, urban accessibility and smart city projects.

Incentive for participation in systems with no explicit social concern

Monetary reward is unquestionably the incentive method that is most widely used by systems that require "microtasks" to be performed. This method was described in 24 papers, in which the researchers' interest was to find the most efficient way of rewarding task performance, making it attractive, while keeping costs as low as possible, to ensure maximum value appropriation by the organization, while preserving the quality of data and diligent execution. Monetary payment are required because the involved tasks are, normally, commercial and do not relate explicit to any social cause that could lead users to contribute out of sole altruism (Chandler and Kapelner, 2013).

Gamification can be used in any type of crowdsensing system. Game elements provide fun and make task performing feel like a hobby, as explained by Bowser *et al.* (2013). Herzberg *et al.* (1993), in the "two-factor theory", point out that a hobby starts without obvious external incentives, strengthening one's intrinsic motivation. An interesting finding related to the use of gamification is the way many systems are designed: typically, gamification features are not part of the main system, whose real purpose is "hidden" within the game context.

Another technique mentioned by some authors was providing incentive for users to engage friends, people that belong to their social networks. Yang *et al.* (2017) remind us that friends who perform tasks encourage other friends to also do so. It is possible to take advantage of the social bonds among participants to promote cooperation, since the incentive that a participant receives depends, to a large extent, on the behavior of other members of his or her social life.

Incentive to contribute to urban accessibility systems and collaborative maps

We subdivided the incentive methods applied to collaborative mapping systems, urban accessibility and smart cities, based on one important characteristic: the commercial or non-commercial intention of the application, as detailed in Table 1. Papers in which the interest is non-commercial, where there is a public interest or social concern, tend to focus on incentive mechanisms that require no monetary reward in exchange for the work that needs to be performed by users, as observed by Chandler and Kapelner (2013).

Project topic	Commercial use?	Incentive methods	Author(s)
Collaborative maps and urban accessibility			
Mapping urban accessibility	No	Gamification Semantic crowdsourcing Visual Cues Altruism	Prandi *et al.* (2016) Mazayev *et al.* (2016) Gonçalves *et al.* (2015) Erraguntla *et al.* (2017)
Accessible public transport	No	Altruism Psychological empowerment	Gonçalves *et al.* (2015)
Collaborative maps - pedestrian navigation	No	Gamification	Bockes *et al.* (2015) Prandi *et al.* (2015)
Wi-Fi based indoor location system	Yes	Monetary reward	Wen *et al.* (2015)
Generating maps of new locations/places	No	Altruism	Basiouka and Potsiou (2014)
Urban planning	No	Points to exchange for products or services – virtual coin Situation at the place of occurrence	Cardone *et al.* (2013) Gonçalves *et al.* (2015)
Mapping of points of interest in the city	No	Gamification Social incentives	Matyas *et al.* (2008)
Other topics			
Search for parking spots on the streets	Yes	Exchange points for a product or service	Hoh *et al.* (2012)
Public transportation	No	Gamification Quid-pro-quo Situation at the place of occurrence	Brito *et al.* (2015) Tomasic *et al.* (2014) Wei and Anwar (2017)
Traffic monitoring	No	Monetary reward	Restuccia *et al.* (2018)
Speed recommendations for crossing the "green light" with bicycles	No	Sense of utility / value added	Fröhlich *et al.* (2016)
Community policing	No	Monetary reward Sense of utility / value added Social factors	Park *et al.* (2018)
Mobile surveillance	Yes	Points to exchange for a product or service	Chou *et al.* (2012)
Map of noise and sound pollution	Yes	Monetary reward	Zheng *et al.* (2017)

Table 1. Incentive methods applied in collaborative mapping systems, urban accessibility and smart cities

Through this SLR, we were able to discover that there are various incentive approaches used to engage users and to get their collaboration in MCS systems. We believe that the combination of some incentive methods presented here may help motivate users to collaborate with an accessible map system like the one we intend to build next. One of the lessons learned from the SLR is that, when designing an accessible map application, we should make clear that the main objective is to achieve a more inclusive city, removing barriers and improving urban mobility for citizens with special needs, therefore getting them to contribute based on altruism and a not monetary reward (Coleman *et al*., 2009; Basiouka and Potsiou, 2014).

Users who take photos that help map a sidewalk, for example, not only help other users to choose accessible ways, avoiding those that do not offer good walking conditions. They also contribute with local authorities, who develop a better understanding of the city's problems and prioritize actions to remedy them. Thus, users' contributions could yield points that could be exchanged, for example, for a discount on bus tickets, tax reduction or even gifts and products from companies partnering in the initiative, as recommended by Cardone *et al.* (2013).

CONCLUSION

This paper presented a systematic literature review about incentive mechanisms to improve user collaboration in crowdsensing efforts. We were especially interested in identifying the forms of incentive used to foster urban accessibility systems and collaborative maps, trying to understand how users' participatory knowledge and effort have been (and can be) used to feed data into and improve those types of system, ensuring that their data is always up-to-date.

One important contribution of this research project was to organize the different incentive mechanisms used in MCS systems. We have identified and detailed several forms of incentive. A matrix of the relationship between those incentives and the types of applications found in the SLR helped us to better understand the types of incentive and what they are used for.

While monetary reward seems to be the most prevalent form of incentive, it is primarily associated with microtasks, which do not require a lot of effort or commitment. Gamification was the incentive mechanism that was more broadly used, having been reported by authors concerned with crowdsensing activities ranging from accessibility and urban mobility to citizen science and health. We also identified other incentive mechanisms that have good potential of mass engagement, such as psychological empowerment.

Remarkably, altruism and other social factors play a modest role as an incentive mechanism for crowdsensing, if the academic literature reflects what is happening in the field. Understanding why it is so may require future research.

As a continuation of this work, we intend to incorporate some of the incentive mechanisms identified in this paper in the design of a mobile application involving an accessible map, updated using crowdsensing and other forms of collective intelligence, to support people with special needs in acquiring information about accessible sidewalks, improving their mobility in the city.

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Appendix – Papers included in the *corpus* of the systematic literature review

Year	Title of publication	Author(s)
2005	Picking Pockets on the Lawn: The Development of Tactics and Strategies in a Mobile Game	Barkhuus *et al.*
2006	Interweaving mobile games with everyday life	Bell *et al.*
2008	Designing location-based mobile games with a purpose: collecting geospatial data with CityExplorer	Matyas *et al.*
2009	Games with a purpose for social networking platforms	Rafelsberger and Scharl
2010	Dynamic pricing incentive for participatory sensing	Lee and Hoh
2010	Crowdsourcing Critical Success Factor Model: Strategies to harness the collective intelligence of the crowd	Sharma
2011	Mobile Image Search via Local Crowd: A User Study	Liu *et al.*
2012	Using virtual credits to provide incentives for vehicle communication	Chou *et al.*
2012	TruCentive: A game-theoretic incentive platform for trustworthy mobile crowdsourcing parking services	Hoh *et al.*
2012	Readers' motivations to participate in hyperlocal news content creation.	Väätäjä
2012	Crowdsourcing to smartphones: incentive mechanism design for mobile phone sensing	Yang *et al.*
2013	Using gamification to inspire new citizen science volunteers	Bowser *et al.*
2013	Fostering participation in smart cities: a geo-social crowdsensing platform	Cardone *et al.*
2013	Motivating crowds using social facilitation and social transparency	Huang and Fu
2013	Disassembling gamification: the effects of points and meaning on user motivation and performance	Mekler *et al.*
2014	Gamification as a paradigm for the evaluation of visual analytics systems	Ahmed and Mueller
2014	The volunteered geographic information in cadastre: perspectives and citizens' motivations over potential participation in mapping	Basiouka and Potsiou
2014	Steered crowdsensing: incentive design towards quality-oriented place-centric crowdsensing	Kawajiri *et al.*
2014	No "one-size fits all": towards a principled approach for incentives in mobile crowdsourcing	Rula *et al.*
2014	Motivating contribution in a participatory sensing system via quid-pro-quo	Tomasic *et al.*
2014	History-based Incentive for Crowd Sensing	Tsujimori *et al.*
2014	WiFiScout: A Crowdsensing WiFi Advisory System with Gamification-Based Incentive	Wu and Luo
2015	Collaborative landmark mining with a gamification approach	Bockes *et al.*
2015	Towards a Framework for Gamification Design on Crowdsourcing Systems: The G.A.M.E. Approach	Brito *et al.*
2015	Mobile Gamification for Crowdsourcing Data Collection: Leveraging the Freemium Model	Dergousoff *et al.*
2015	Privacy-Respecting Auctions as Incentive Mechanisms in Mobile Crowd Sensing	Dimitriou and Krontiris

Year	Title of publication	Author(s)
2015	Truthful Incentive Mechanisms for Dynamic and Heterogeneous Tasks in Mobile Crowdsourcing	Fan *et al.*
2015	Motivating participation and improving quality of contribution in ubiquitous crowdsourcing	Gonçalves *et al.*
2015	Crowdsourcing with trembles: Incentive mechanisms for mobile phones with uncertain sensing time	Ji *et al.*
2015	Quality of Information Aware Incentive Mechanisms for Mobile Crowd Sensing Systems	Jin *et al.*
2015	Pay as How Well You Do: A Quality Based Incentive Mechanism for Crowdsensing	Peng *et al.*
2015	From gamification to pervasive game in mapping urban accessibility	Prandi *et al.*
2015	Quality-Driven Auction-Based Incentive Mechanism for Mobile Crowd Sensing. IEEE Transactions on Vehicular Technology	Wen *et al.*
2015	Incentive Mechanisms for Time Window Dependent Tasks in Mobile Crowdsensing	Xu *et al.*
2015	Crowdsourcing energy-efficient participants to ensure quality-of-information	Zhang *et al.*
2015	Incentive Mechanism Design for Smartphone Crowdsensing	Zhang *et al.*
2016	An integrated incentive framework for mobile crowdsourced sensing	Dai *et al.*
2016	BikeNow: a pervasive application for crowdsourcing bicycle traffic data	Fröhlich *et al.*
2016	Urban sensing based on human mobility	Ji *et al.*
2016	Improving Accessibility through Semantic Crowdsourcing	Mazayev *et al.*
2016	Adopting incentive mechanisms for large-scale participation in mobile crowdsensing: from literature review to a conceptual framework	Ogie
2016	Walking with Geo-Zombie: A pervasive game to engage people in urban crowdsourcing	Prandi *et al.*
2016	Engaging people to participate in data collection	Tobien *et al.*
2016	An incentive mechanism with privacy protection in mobile crowdsourcing systems	Wang *et al.*
2016	Incentive Mechanisms for Crowdsensing: Crowdsourcing with Smartphones	Yang *et al.*
2016	A Fair Incentive Mechanism for Crowdsourcing in Crowd Sensing	Zhu *et al.*
2017	Promoting Cooperation by the Social Incentive Mechanism in Mobile Crowdsensing	Yang *et al.*
2017	Toward Efficient Mechanisms for Mobile Crowdsensing	Zhang *et al.*
2017	A Budget Feasible Incentive Mechanism for Weighted Coverage Maximization in Mobile Crowdsensing	Zheng *et al.*
2017	Mobile-Based Sidewalk Inventory App for Smart Communities, Health, and Safety	Erraguntla *et al.*
2017	EGAIM: Enhanced Genetic Algorithm based Incentive Mechanism for Mobile Crowdsensing	Saadatmand and Kanhere
2017	Analysis of motivation approach in mobile crowdsensing application: Specialize on public transportation domain	Wei and Anwar
2017	Robust Incentive Tree Design for Mobile Crowdsensing	Zhang *et al.*

Year	Title of publication	Author(s)
2017	Incentive mechanism for participatory sensing: A contract-based approach	Zhonghui *et al.*
2018	Tamper-Proof Incentive Scheme for Mobile Crowdsensing Systems	Calado and Pardal
2018	An Incentive Mechanism for Crowdsensing Markets with Multiple Crowdsourcers	Chakeri and Jaimes
2018	An Identity Privacy Preserving Incentivization Scheme for Participatory Sensing	Connolly *et al.*
2018	Wirelessly Powered Urban Crowd Sensing over Wearables: Trading Energy for Data	Galinina *et al.*
2018	CampusWatch: Exploring Community sourced Patrolling with Pervasive Mobile Technology	Park *et al.*
2018	Social-aware incentive mechanism for full view covered video collection in	Pei and Hou
2018	IncentMe: Effective Mechanism Design to Stimulate Crowdsensing Participants with Uncertain Mobility	Restuccia *et al.*
2018	BRRA: A Bid-Revisable Reverse Auction based Framework for Incentive Mechanisms in Mobile Crowdsensing Systems	Saadatmand and Kanhere
2019	A Stackelberg Game Approach Toward Socially Aware Incentive Mechanisms for Mobile Crowdsensing	Nie *et al.*
2019	An Incentive Mechanism Design for Socially Aware Crowdsensing Services with Incomplete Information	Nie *et al.*
2019	Incentive Mechanisms for Mobile Crowdsensing with Heterogeneous Sensing Costs	Zhang *et al.*