Entertainment beyond Divertissment: Using Computer Games for City Road Accessibility

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Computer games represent today one of the most important businesses in the IT industry, as well as one of the prominent means of entertainment chosen by children and adults. Their popularity in the contemporary world society has led many researchers to think how they could be put to good use to improve the education of players engaged in a game. In this work we present a game that goes beyond this paradigm, which is centered on single persons and pervasively relies on players to pursue a service that may be useful to a community as a whole. The game we here propose collects and processes information about the accessibility of city roads to build paths that may be approached by people with impairments. Players that join the game are rewarded gaining points and positions in the game ranking for each reliable piece of information they provide. Accessible paths, built taking into account such information, can be accessed through a Google Maps-like service which computes the shortest and safest path, for a person with a certain degree of disability, between any two given origin-destination points.

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General Terms: Design, Performance.

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1. INTRODUCTION

Revenues produced by electronic games represent today one of the most important items on the income statements of many diverse industries (e.g., publishing, film making, sports, etc.). Leveraging on the wide popularity of video games among all the segments of the consumer market, researchers, educators and many other professionals have exploited in the past, and keep exploiting today, the use of computer games to convey positive messages to players. Such process has led to the creation of a whole new domain of games, termed *serious games*, that use technologies and other interesting features of games in order to create applications that stimulate serious purposes: for example, the acquisition

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of good principles (e.g., solidarity, diversity, inclusiveness, social and civic awareness), the pursuit of a physical training (e.g., for leisure or as a therapy), or the construction of a solid education foundation (e.g., learning history, math, geography, etc.) [Unesco 2010; Michael and Chen 2005].

However, a wealth of research carried out in the past few years by many prominent medical practitioners, psychologists and sociologist, concludes that any game may be considered serious. Any game, in fact, besides entertaining, also hides one or multiple secondary objectives, that often correspond to some serious purpose. In such sense, games are playing the important role of *edutaining*, rather than solely entertaining. Nonetheless, most computer games today create an individual relationship with their players, providing their benefits on a single player basis, thus usually ignoring communities of people. Instead, in the era of Web 2.0 and pervasive computing, more can be done that can be beneficial for the society as a whole [Weiser *et al.* 1999; O'Reilly and Battelle 2009]. In some sense, the teamwork among players could produce results that are more significant than those that would be achieved by any individual [Ferretti *et al.* 2010]. Scenarios exist where all players, enjoying a game, could provide a service to a whole community, rather than solely to themselves. Examples emerge where the benefit of gaming together is rerouted towards very special communities, such as those composed by people with physical impairments.

To provide a concrete proof that gaming may serve such purpose we are going to describe the example of a game we designed and implemented, with the aim of delivering a useful service to people with impairments. Before proceeding with this example, we must remind that unfortunately a relevant number of cities, especially those supplied with old road and sidewalk infrastructures, do not provide pedestrians with easy and comfortable ways of accessing their streets, thus requiring walking around or jumping over many obstacles [Völkel *et al.* 2008].

Solutions have been proposed by researchers to support mobility-impaired pedestrian through specifically designed route generators [Völkel and Weber 2008; Holone and Misund 2008; Kasemsuppakorn and Karimi 2009; Beale *at al.* 2006; Sobek and Miller 2006]. However, these solutions are based either on the existence of accessibility information related to each road, or on the active participation of users that should create and augment geospatial data. Yet, the crucial problem of gathering accessibility information for every road still remains unsolved.

One possible solution may leverage on those people that, due to a permanent disability or to a temporary illness, are forced to move around one of such cities on a wheelchair. These people create their knowledge on how to move around their neighborhood, or how to reach their job site, from a frustrating trial and error approach that leads them to determine the accessible routes in their area of interest. However, the road accessibility knowledge that is individually created by all the people that walk around a neighborhood can be put to good use for the greater good: all the routes generated by all users can be combined and later used to establish not only the shortest path towards a new destination, but also the most suitable route for people moving on wheelchairs, hence improving city road accessibility. Such service, which we implemented as a serious game, performs the following tasks:

1. The smartphone belonging to each person with impairments records the regular routes of its owner (leftmost part of Fig. 1);
2. Any user (both with and without impairments) may actively provide the centralized server with a detailed report on some encountered obstacle (e.g., by uploading a photo, video, text or audio fragment) or its own evaluation of its most frequently utilized road segments (rightmost part of Fig. 1);
3. The centralized server, in turn, while collecting all this information also processes it, identifying the paths that best result to be accessible to wheelchairs;
4. Any user on a wheelchair that needs to walk through an unfamiliar area can query the centralized server asking for the safest and most accessible route, also indicating that she/he will be traversing the area on a wheelchair;
5. The centralized server computes and returns the most suitable route for a person that moves on a wheelchair (Fig. 2, accessible roads are highlighted in purple).

Clearly, the abovementioned steps provide a useful service; yet, it is based on the assumption that people will participate by sending their evaluations of roads' accessibility. It is hence crucial to motivate users in participating in such task. To this aim, a game could be created so as to induce people in performing evaluations of their best known streets. We have hence devised a rewarding scheme, where each player, when providing useful information, wins a number of points. In some sense, our approach extends the Google Image Labeler idea in which rather than simply classifying images, participants classify streets. Upon deciding to deploy such system, we immediately thought that the best way of implementing it was integrating it with the Google Maps service, which already offers a way of easily determining the best routes for cars and pedestrians without disabilities.

PathManager2.0

PathManager

Latitude:**12.28534**

Longitude:**44.50734**

PATH FINISHED
No correspondence address
Duration: Hr: 0 Min :0 Sec: 13
Distance: 40.417 Km

Exit

PathManager2.0

In recent days you've walked this route many ti...

Sufficient Road ○

Adequate Road ○

Good Road! ○

Excellent Road! ○

Exit

Fig. 1. Accessible road management.

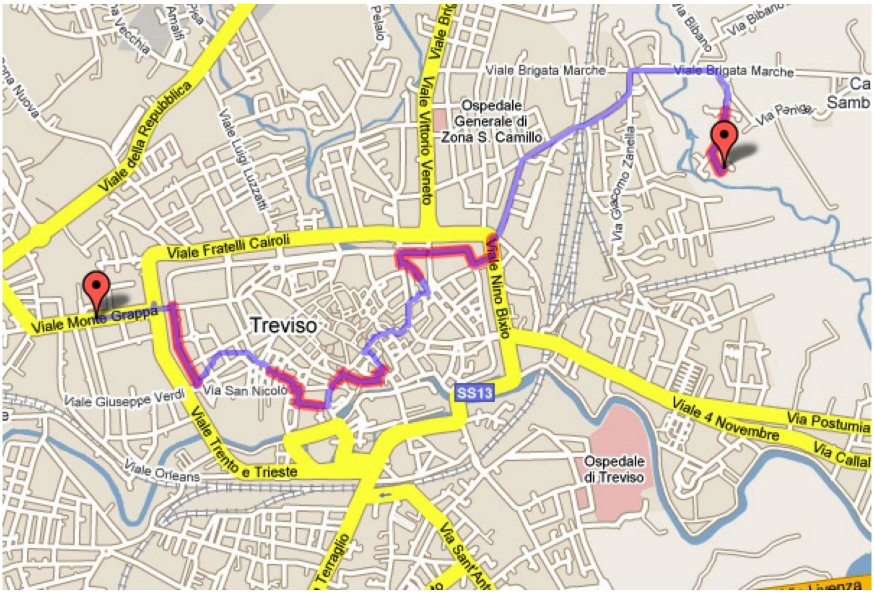

Fig. 2. Example of an accessible path.

In summary, such type of game can serve two purposes. First, it would encourage the provisioning of a service useful to people with impairments. Second, it would increase the players' awareness for problems that are seldom considered. For these reasons, we believe that as this and similar approaches can increase the awareness of people for problems that are disregarded by most. We should all think of new and smart ways of answering the many challenges that can be approached leveraging on serious games, since the beneficial effects of technology should be for all, regardless of physical impairments.

The rest of this paper is organized as follows. In Section 2 we describe how our game works through a practical example, while in Section 3 we explain how players are rewarded, while providing accessible routes. Section 4 describes how the game is implemented and Section 5 summarizes a few experiments that prove the validity of our approach. We finally conclude with Section 6.

2. FROM AN ACCESSIBILTY SERVICE TO A SERIOUS GAME

Our application is named *Path 2.0* and is aimed at providing people with impairments with information that can improve their lifestyle; more specifically, with information that may increase their easiness in moving around an urban area. This purpose is achieved exploiting the capabilities of Smartphones, which are equipped with a digital map and a GPS receiver, as follows.

One of the main tasks of Path 2.0 is to collect information about users' *regular paths*. These are paths that are frequently utilized, and hence probably well known, by users. Once the regular paths of each user are identified (e.g., our algorithm extracts a regular path as a path that is performed several times at a walking or wheelchair speed), these can be sent to a centralized server, which in turn fills a database with such information.

The accessibility information of any road will then be available through a Google Maps-like web interface. In particular, if a user can only move on a wheelchair and needs to find the most suitable path between where she or he is and a final destination, the user can access the web interface and find how to reach it. The path is the most suitable because, differently from what Google Maps does, Path 2.0 computes a route that takes into account the disability of the person that issued the query and all the information, provided by all users, regarding the accessibility of the roads close to that area.

In order to better explain a possible scenario, consider Fig. 3, where A, B and C represent three regular paths that three users with impairments, Andrew, Becky and Carl, respectively, utilize very frequently. In particular, Andrew uses path A to reach his workplace every day; Becky, once a week, walks along path B to see a friend, while Carl, every other day, takes route C to reach his physician's office. Clearly, given that Andrew, Becky and Carl feel comfortable in taking such paths to reach their destinations at least once a week, we can assume that these paths are compatible with the impairments of their respective users.

Now, let us also assume that Andrew, Becky and Carl use Path 2.0. Their regular paths A, B, and C, hence, are periodically fed to a centralized server and advertised through a webpage. Such information can be put to good use by a fourth person with physical disabilities that is not very familiar with the area where A, B and C lie and wants to move between the positions marked in Fig. 3 as *?* and *ARRIVAL*, for example. If this person, say Derek, desires to find the path that best suites his needs, he can access the Path 2.0 webpage and request the best path between the two locations of interest. The centralized server answers such request retrieving the information concerning paths A, B and C from its database and returning the shortest possible route that meets Derek's needs in terms of accessibility.

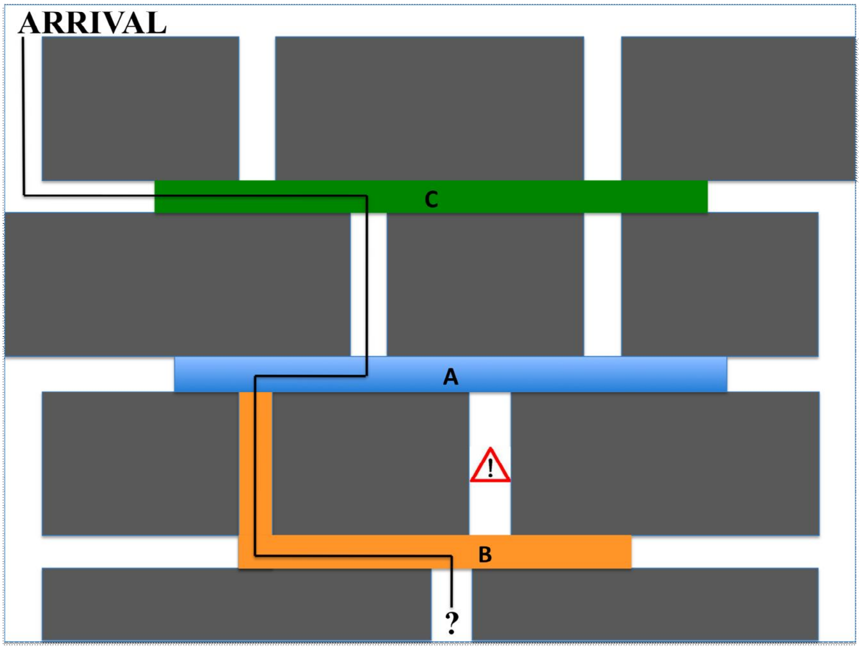

Fig. 3. Example of construction of an accessible path.

In general, a mechanism as the one that is implemented in Path 2.0 can meet the needs of different classes of users, thus not only those suffering from mobility problems. For this reason users can also specify their type of disability in the system, for example saying whether they can only move using a wheelchair or a walking stick or also indicating that they are interested in receiving routes suitable for people with very limited eyesight. In this way the regular paths uploaded by certain classes of people can be easily matched to people that fall within the same class and, hence, that experience the same requirements.

Clearly, such service is progressively more effective as more people upload accessibility information. Yet, relying on people's altruism in tagging roads may not be enough and paying operators to this aim would be too expensive. In order to motivate people in participating we propose the implementation of a serious game in Path 2.0, where evaluating regular paths provides game points to players. Indeed, it is important that players are enabled to evaluate only their regular paths otherwise they could cheat and provide as many evaluations as possible even if they have never been in a certain road, just for the sake of gaining game points. In the next section we explain the rewarding mechanism we devised to assign points for each useful piece of information that is provided.

3. REWARDING STRATEGY

In order to ensure the contribution of as many people as possible, willing to provide accessible paths to the centralized server, we devised a serious game for Path 2.0, where each player receives points for the information she or he provides.

In this section, we briefly describe how points are assigned to players. Each player can easily advertise the status of a path by highlighting it on her or his smartphone and assigning an accessibility value to it. As shown before in Fig. 1, accessibility evaluation can be positive or negative. Moreover, they could be expressed in numerical values (e.g., ranging between -10 and 10) or simplified as shown in Fig. 1 (rightmost part). In the latter case, to each evaluation the system assigns a specific numerical value (e.g., “Excellent Road” = 10, “Good Road” = 8, etc.).

If a player, say Mark, assigns to a certain path P an accessibility value of 8, then Mark receives as reward a number of points equal to the length of the evaluated path in meters. After that, if Mark was the first player to assign an accessibility value to P, his score increases by the 20% of the length of P as more players confirm that it is accessible.

If instead Mark finds that a path, say path Q, is not accessible, then he is entitled to receive twice of the points corresponding to the path length in meters. However, to receive these points he needs to perform the two following steps. First, take a picture of the barrier that compromises the accessibility of the road and, second, assign a negative score to the path. After uploading the picture and the path accessibility value, the centralized server stores such information in its local database. When accessing the service on the Google Maps-like interface users are also able to check why a path is not accessible by viewing the picture of the road, just as in Panoramio. Even in this case, as before for positive evaluations, first comers are favored by the fact that if any other player later confirms their judgment, they will receive more points (20% of the length of Q).

In summary, this rewarding scheme aims at encouraging players to explore new paths and provide new information, rewarding particularly those that first assign an accessibility value to a path.

4. DEPLOYMENT AND EXPERIMENTATION

We have actually implemented Path 2.0 and, in this section, we provide technical details.

First, on the client side, in order to guarantee its diffusion, we decided to utilize Google Android as the smartphone platform. This choice is supported by the fact that Android's market share is steeply increasing and that its source code is released under an open source license, hence providing a friendly environment for developers. Our application is completely developed in Java, thus easing its portability to the vast family of handsets that is equipped with a Java Virtual Machine.

The client application life cycle is composed of three main phases, which are sequentially repeated, to identify a path. First, by periodically polling the GPS for its position, our application, the PathManager, determines that a path started checking whether the user left its original position moving more than M meters away at a walking or wheelchair speed. Second, the PathManager removes cycles, checking whether the user left and returned within L minutes to the initial point. Third, a path ends when the user stands in the same position for a minimum time X. Once a regular path has been determined, it can be proposed to the user to be evaluated before forwarding this information to the central server.

On the server side, we deployed a database to store the XML formatted regular paths sent by the PathManager of each smartphone running the Path 2.0 serious game. Within our XML representation, regular paths are composed by several latitude-longitude pairs and have a *weight* attribute indicating their accessibility level. In such context increasing positive weights correspond to higher levels of accessibility of roads. A negative weight, instead, indicates that a path is non-accessible.

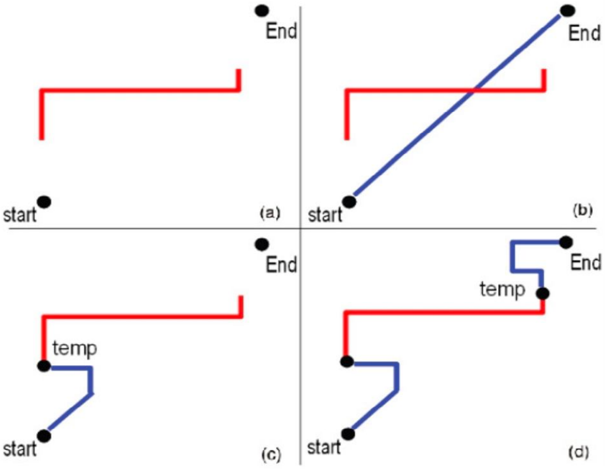

Fig. 4. Construction of an accessible path.

On receiving a new regular path, the server at first checks whether the route (or a portion of it) has already been stored in its database; coherently, it then creates a new entry or update the average evaluation of existing ones. This information is then exploited to generate a Google Maps-like service that accepts queries and returns accessible paths between any origin-destination pair. The path creation system, a central part of Path 2.0, implements an algorithm that is based on the Google Maps APIs, and in particular on the following methods: (a) `getDirection(pointX, pointY)`, which returns the set of coordinates that compose the shortest path between `pointX` and `pointY`; (b) `distanceTo(pointX, pointY)`, which returns the distance in meters between `pointX` and `pointY`; (c) `draw(Route)`, that graphically displays a path on map. When a user selects an origin-destination pair on a map, the system first resorts to Google's APIs to compute a route, as Google Maps would normally do. The given route is then broken into subparts, which the path creation algorithm verifies to check their accessibility degree. If any subpart is inaccessible for any reason, the algorithm searches for an accessible path in the area that may substitute it. The algorithm then proceeds computing the route from the final point of the new sub path to the final destination. Such process can be recursively repeated, until the entire path is guaranteed to be accessible.

This concept can be easily appreciated resorting to Fig. 4, where part (a) shows the creation of a path between *start* and *end*, close to an accessible section (red line in the figure). In part (b) of Fig. 4 the blue line represents the fastest walking distance obtained from Google Maps.

Parts (c) and (d) of Fig. 4, instead, display the two steps that are required to build a new path which utilizes the known accessible route.

5. EXPERIMENTAL EVALUATION

We have performed a preliminary experimental evaluation of our approach which comprises the assessment of the path generation system. More in detail, we have created a database including roads evaluations. For the sake of realism, we have to assume that not every person will play and that not every road will be evaluated. Therefore, we configured our database so as to include the evaluations (with values uniformly distributed) of 20% of the roads in a certain area of interest.

In this scenario we are interested in measuring how responsive the system will be when asked to provide an accessible path depending on the distance between the beginning and the end of the path. Clearly, this waiting time also depends on the complexity of a topology, i.e., on the number of road sections included in the path, as for each of these sections the system has to retrieve the accessibility information from the database and then interrogate the Google Maps server through the `getDirection()` call to obtain the new possible path to reach destination as described in Section 4 and Fig. 4.

In our experiments we considered an Italian town, Treviso, and a maximum cellular download speed of 4 Mbps. The utilized Google Maps server was regularly active and hence busy with regular path requests from Internet users. We performed several experiments at different times of the day; results can be seen in Table I. More in detail, we report the distance between the departure and the arrival points of the user, the number of road sections with accessibility information that were utilized to compute the suggested accessible path, the number of queries that had to be performed to the Google Maps server to obtain the final path and the average response time.

The outcome clearly demonstrates that the response time depends on the distance between the departure and the arrival points of the user but also on the complexity of the path which can be expressed as the number of queries to the database and to the Google Maps server.

Table I. Response time: experimental evaluation.

Departure-arrival distance	**Used sections from DB**	**getDirection() calls**	**Path 2.0 avg response time**
100 m	1	3	906 ms
2000 m	3	9	3923 ms
4000 m	4	12	7097 ms
4000 m	6	18	8036 ms

As a conclusive remark, we would like to point out that no experiment exceeded 10 s of response time if considering a distance of 4000 m. This represents an acceptable time upper bound as, generally, a user (i.e., a pedestrian or a person on a wheelchair) queries for much shorter distances.

6. CONCLUSION

With this work we aimed at converting the effort that many people put in computer games into an effort to improve the quality of life of a community. Our Path 2.0 serious game goes beyond the paradigm of users playing for their personal rewarding; instead, by playing, a service useful to a community as a whole is generated.

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