# CitySkin: Which Color Is Your City?

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**Abstract.** Mobile phones are becoming ubiquitous machines with increasing processing power. This paper will focus in discussing an experimental application, CitySkin, which relies on mobile phones for data retrieval with mapping purposes. This mobile visual system provides an accessible mean to design an invisible skin of a city (an output map) following a user point of view at a given moment in time. This project explores relations between subjectivity and raw data by combining hard data with visual mapping. Cities and their intrinsic diversity can be compared. Slightly different input variables can present greater changes in a recurrent path. CitySkin records the mood of a specific derive discussing the cultural implications on computing and the design of its ubiquity.

**Keywords:** Data visualization · Mapping · Ubiquitous computing · Digital art · GPS referencing

## 1 Introduction

According to Weiser and Brown the concept of Ubiquitous Computing (U.C.) aims to create "a calm computing" achieved by having computers disappear (Weiser and Brown 1996). This is made possible by conveying computing surrounding humans as part of environments. U.C offers a perspective that emphasizes human and social aspects, presenting computation as an open definition (Denning 2011) challenging its terms, significance and appearance.

U.C. discussion is translated into projects that combine research and life. For instance, contributions can be observed given by the progressive miniaturization of sensors and actuators, as to the exploration of smart materials (Coelho and Zigelbaum 2010) but also by applying natural structures to design (Oxman 2010) as well as Maeda's bits, atoms and crafts research (Maeda 2018). These relations inspire hybrids of several form and nature. Moreover, some authors (Kim and Symonds 2010) defend that we are fully living in a UC era, considering that this ubiquity of computation is made real with the use smartphones. CitySkin research project acknowledges this last statement and aims to contribute with a proposal that tackles the hybridization of art with science.

In the last decade, mobile phones became a common tool for communication in a post-industrialized world (Castells et al. 2006) but also in developing countries. When analyzing the spread of mobile phones use in a globalized world, the appeal lies on


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**Fig. 1.** CitySkin image output: driving for 33 min.

the emotional tie and social implication given by a personal object. But on the other hand, it is relevant to the context of CitySkin project, to mention the iniquity on existent access to different features provided by mobiles phones, but also the network coverage quality, factors that are definitive to better define the audience. It is relevant to say that smartphones are still a "first world" tool, which translates to context CitySkin in terms of accessibility.

Smartphones are used as a tool. They combine their computing, mobility, and mapping possibilities. Smartphones beyond having an exponential computing power, commonly have features as WI-FI, 4G and 5G network connection, GPS, accelerometer, high quality camera, commonly in people's pockets. These particular features offer a realm of possible combinations.

In addition, CitySkin project, addresses consequences of digitalization of information and big data. Tools such as smartphones have created an exponential ability to collect and store massive amounts of information. On one hand, this massive amount of information generation brought forward the need to improve their readability. The exponential growth of information has found in graphic visualization a model to simplify the interpretation of data complexity. Data visualization not only improves reading, as creates rich aesthetic experiences, adding new perspectives to visual and cultural discussion while conveying digital information. All these solutions have been made possible by mutual contributions arising from computer science and art. Examples of these prevailing collaborations can be found in current definition of design made by institutions such as NY MoMA, in the Design and the Elastic Mind (MoMA 2008), Talk To Me (MoMA 2011) and Design and Violence (MoMA 2015) exhibitions commissioned by Antonelli or in the Linz's Ars Electronica (Ars Electronica 2019) a festival where, since the 70's, science and art collaboration is discussed and celebrated. However Data Visualization is also a prevailing visual experience distributed in Internet under several categories and by a myriad of authors.

CitySkin's conceptual design is inspired by these approaches, and uses computation to measure and visualize routes inside the city. It references mapping, data visualization, and digital art critic (Crampton 2009; Tufte 2006; Hall 2006) but also makes a contribution for the shifting concepts on computing. Cityskin draws a visualization to hard data by proposing a literal and psychogeographic journey, considering human subjectivity, in an implicit invitation for derive, surprise and improvisation (Debord 1958).

## 2 Related Work

Background of experimental mobile applications is found in the context of digital art. Since the beginning of the public internet that terms like "internet art" attributed to extended nomadic networks have emerged and have been explored by digital artists. In this context, the particular designation of "software art", coined work that referenced formal outputs given by computational instructions.

Since the 90's, artists like Golan Levin have presented work that rely on software features. Golan Levin created interactive software that allowed manipulating visuals and sounds in real time. Telesymphony is a project that extends Golan's work to nomadic devices. Sound is generated by the ringtones of audience's mobile devices (Paul 2008).

Mapping is an excellent conceptual tool to understand and cope with urban landscape information. Considering U.C. and Data Visualization strategies, cities that dwell with interchange of massive information, are becoming progressively U-Cities (Hwang 2008), this meaning, Ubiquitous Cities. MIT SENSEable City Lab ("MIT Senseable City Lab" 2019) has contributed to U-Cities research with several projects. One of these projects, trash track ("trash track" 2018) attaches sensors to discarded objects and maps its path until the dump. The output map gives awareness to the existence of long trails, as opposed to a more efficient proximity system, indicating waste of resources in an immediate way. Projects like Pedro Cruz and Machado (2016), Lisbon blood vessels uses veins in circulatory system as a metaphor to visualize, with aesthetics appeal, Lisbon's traffic flow. This method can also give real-time valuable information to drivers.

A growing number of designers and researchers are using data visualization technics for artistic expression, but also the particular features on mobile phones as survey machines. GPS, wi-fi, embedded camera, computation, in addition to mobility, are presently used and mixed in different approaches. MobiSpray by Jürgen Scheible uses mobile phones as an artistic toll to paint digital graffiti. Scheible created a client server application that uses mobiles as gesture-control (Scheible 2009). Mobiles are used as pointing mechanism drawing on a video-projection, thus, creating digital public art. Large scale drawing using mobile devices is another example of the GPS use for artistic expression, and a concept presented by several artists ("gpsdrawing" 2018).

Travelling inside a city deals with relations between time and space, i.e. geography, time measurement and a less obvious category, a degree of fun. Enjoyment is the one addressed by Mark Shepard's in experimental mobile application Serendipitor (Shepard 2011). The same is expressed by Atau Tanaka and Petra Gemeinboeck in "Net derives" (Tanaka and Gemeinboeck 2006). Serendipitor is part of a broader project, Sentient City, which tackles with design of the city of the future. Serendipitor is an i-phone application that invites the user to explore different paths in a city map. It calculates alternative ways to get to a particular part of the city, with inherent proposals to diverge. "Net derive", also follows the concept of derive, transforming the city in an instrument. Mobile phones, using GPS position, camera and microphone, exchange information between spectators in a gallery and three participants in the streets of a city. Sounds and pictures from the streets become information to visualize and sonificate locations.

Finally, two experimental mobile applications from Japanese company Aircord, show how playfulness can be aesthetically relevant and simple (Aircord 2018) The first virtual free runner is an animated man that reacts to accelerometer with a tap to jump button, to be used with a projector.

## 3 Design Principles

### 3.1 Art Concept

Describing time visually has always been a concern with clear practical implications in life from the beginning of times. Current time measurements have implicit computations based in sky observations. It is relevant to look into history of science and math. These time divisions originated from computations made in the beginning of civilization, 4000 years ago, in Mesopotamia. Surviving Babylonians' clay tablets records show cumulative data from sky observations that throughout time allowed predicting celestial phenomenon with precision. For instance, it was an ancient civilization that gave 7 days to the week.

The number seven had a mystical significance to Babylonians. It was associated with the seven heavenly bodies: the sun, Mars, Mercury, Jupiter, Venus and Saturn. As such, the measurements of the week that are still in use today are based in astronomical observations made in ancient past.

Mesopotamians' great mathematics put forward a 60 base system, which allowed defining the sixty minutes in the hour, and the 360° of the circle (Fara 2009). The sexagesimal system is useful to measure angles, geographic coordinates, and time. Mesopotamian representation of time was created from a circle division, having different attributions to year, month and day. These divisions of time were also based in astronomical observations. For instance, the month division correlates with the observation of the moon. To some extent, and considering some alterations, this system created by ancient mathematicians is still used embedded in our high tech life, and use in the apps in our mobiles phones.

This leap in time, and historical background gives understanding of cultural implications of time division, but also indicate a clear relation to direct observation of natural elements. These divisions depend on interpretation and record of celestial moving objects and therefore have an implicit design (Fig. 2). CitySkin is also inspired by this convention of time measurement that relies on observation. Using mobile cameras as a metaphor of the eye, and giving direct relation with geographic space, by GPS location recording,

**Fig. 2.** Part of a clay tablet, 3 pieces, Neo-Assyrian. A copy of the so-called Venus Tablet of Ammisaduqa (detail) The British Museum, retrieved from https://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=314745&partI

CitySkin provides visual maps of travels that connect locations and time. It uses a pre-defined computational model (based in the number 60 as a direct quote of Babylonian measurements). The result is a graphic map that will give an impression of a particular city at a given time.

### 3.2 Prototyping

The prototyping studies began by physically travelling the city by car, and defining a path. First trial was a crossing over Tagus River, from the South bank, the city of Almada, to Lisbon, in the North Bank (Fig. 3). The journey took 33 min.


**Fig. 3.** Prototyping the journey between Almada and Lisbon

Throughout this travelling, one photo was taken roughly each of the 33 min using a mobile phone (Fig. 4).

These photos were used to output map studies, by stretching, adding filters, and searching for a visual result that was focused on color. Mainly, creating a map of colors predominance within a specific trip (Fig. 5 and Fig. 6).

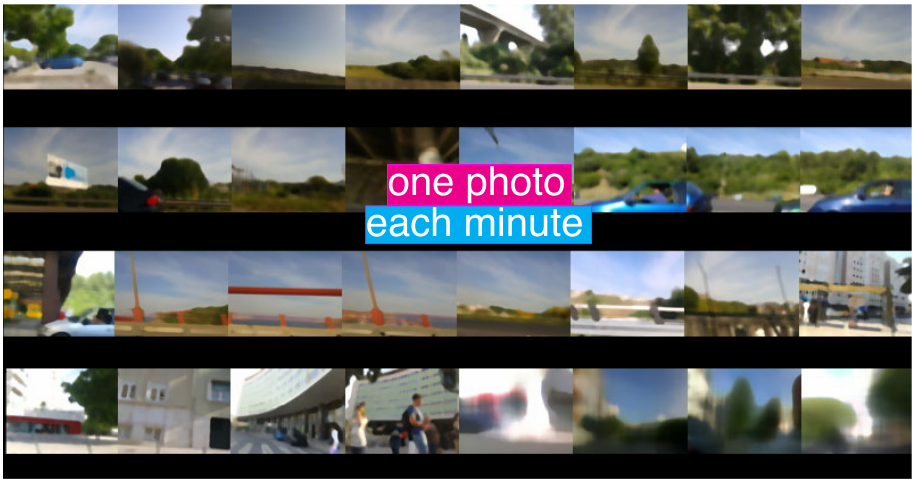


**Fig. 4.** Prototyping: taking one photo each minute

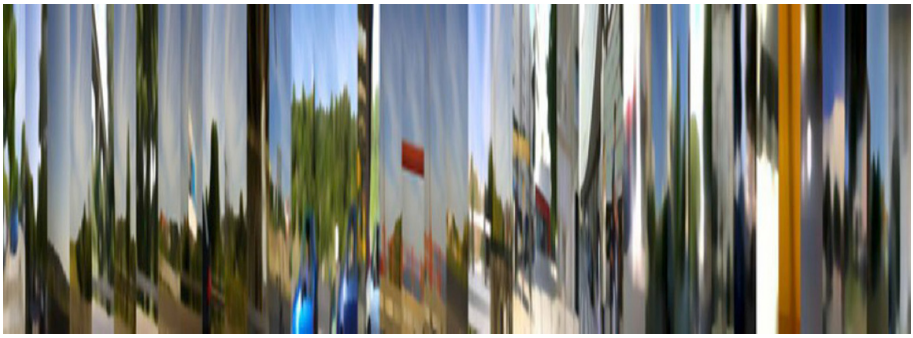

**Fig. 5.** Output color map number 1 test using photos from Fig. 4. (Color figure online)

**Fig. 6.** Output color map number 2 test using photos from Fig. 4. (Color figure online)

### 3.3 Design

The application design follows the prototyping results. The final graphic map (skin) results from photos taken during an up to 60-min journey, by foot or in a vehicle. Cityskin takes a photo each minute and has its location recorded. The difference between position

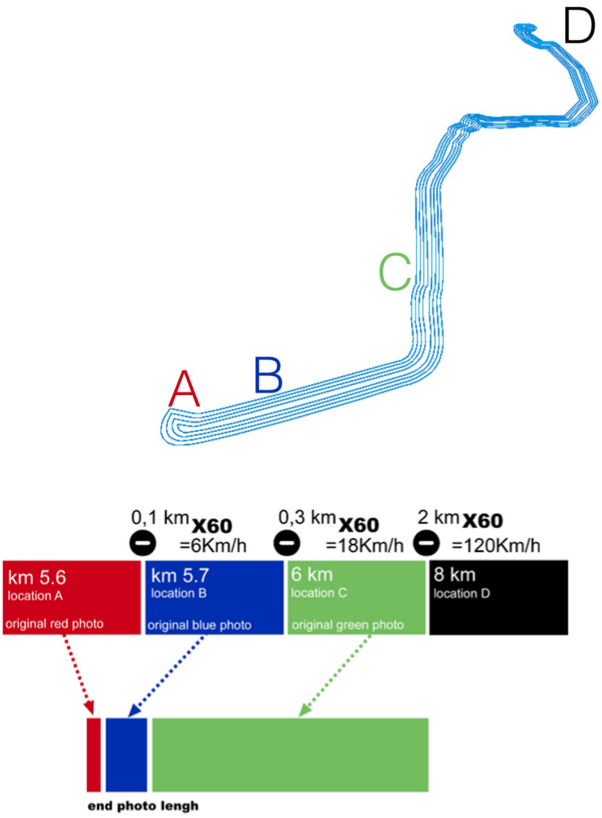


**Fig. 7.** Image length computation

A and B will define the velocity and this value determines each photo final length (Fig. 7). A median filter is applied to each photo, in order to emphasize color, and its length is compressed or stretched according to the velocity variables. These images are lined horizontally, and a white space is kept between them. The white space adds readability to each picture, but also becomes an editable input text space.

GPS coordinates are presented as default text between stripes. The users are allowed to substitute this geographic information by editing their own text labeling in each white line (Fig. 8). The final map results from a representation of hard data and open variables related to movement and color – visual impressions, time, type of transportation and user input.

The final map will be presented as a stripe of colors, showing long stripes when the user is moving faster, and narrower stripes when the user is moving slower.

### 3.4 Technology

The first implementation test was made for iOS. CitySkin output corresponds to a single JPG image file (Fig. 1 and Fig. 11), containing the GPS coordinates of each of the

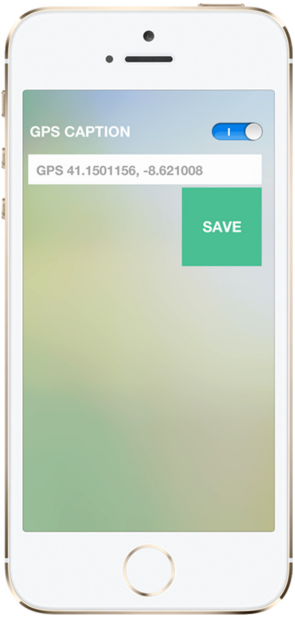


**Fig. 8.** U.I. input text screen

images captured, with photos taken each minute. The final image directly represents the path taken by the user, synthesizing the user perspective and the particular variables associated to the travel.

This final skin output can be shared. The jpg format image is aimed to either be published in socials networks or sent via e-mail.

### 3.5 Designing Relations: Objective Derive

Quotidian journeys are often a routine experience where landscapes blur into oblivion. CitySkin can provide insights about different layers of perception, and a singular perspective. The application invites the user to find different maps around the known but also unknown places.

The measurement method is inspired by Babylonian direct observation of celestial phenomena. As such, Cityskin is offering an interpretation on data given from visual cues. CitySkin can visualize and find interesting differences, coincidence or patterns on journeys maps.

It becomes possible to compare visuals from different cities, but also the subjective variables given by an individual journey. These changes can be given by time spent in different locations, or even provoked by the user's imagination.

CitySkin was designed considering that identical paths would provide completely different maps accordingly to the use, emphasizing the differences around the experience found in routine.

### 3.5.1 Sharing Images

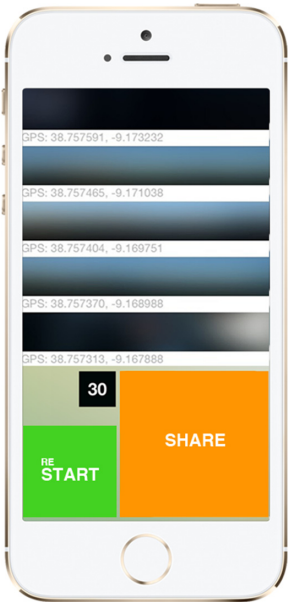


**Fig. 9.** User Interface: share screen

One of the main features of CitySkin application (Fig. 9) is the ability to share output. This feature is designed to support a ritual of communication, this being, according to Mikko Villi (2010) often more important than the photographic quality itself. Also, it has been noticed that photo sharing rituals are followed by text message practices, i.e. often images do not substitute texting.

CitySkin combines image and texting, and opens directions and opportunity for experimentation concerning the combined use of image and texting, as a common way of communication.

## 4 Issues and Solutions

### 4.1 Human Variables and Algorithm

CitySkin's visual variations depend on velocity, which determines each stripe picture's length. This variation, however, brought the necessity to distinguish walking from a vehicle journey, because velocity has implications in the final design (Fig. 10). Accessing two different algorithms solved the issue, accordingly to user input determination of velocity, either walking or travelling in a vehicle.

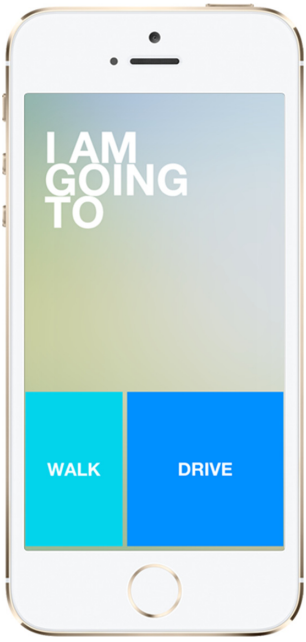


**Fig. 10.** U.I. drive or walk screen

### 4.2 Identifying Location

CitySkin's computation depends on a correct identification of location (Fig. 11), using GPS by default. As noted by several authors (Kerr 2019; Liao et al. 2006) GPS referential location has problems. It is common for mobile phones to lose signal indoor, making GPS based projects only suitable for outdoors. The lack of accuracy is also observable.

CitySkin invite users to test the application in excellent conditions. When that is impossible, the geographic information can be manually inputted as referenced. In the absence of the user labeling, CitySkin will use an average measurement.


**Fig. 11.** GPS default graphic aspect – CitySkin in Helsinki (GPS: 60.173294, 24.936304)

## 5 Future Work

CitySkin is a work-in-progress project. Next steps will include system evaluation aiming to refine the user experience. Also it will be made accessible to other platforms, as Android and Windows. Also we aim to integrate the distribution of Cityskin's output in the website.

## 6 Conclusion

Cityskin project tests relations between computation and art, acknowledging the incremental computation ubiquity allowed by mobile phones. Ubiquitous Computing is addressed by this application, considering cities intelligence. In a broad sense proposes to test playfulness and a sense of discovery, thus, giving focus on the user experience. CitySkin produces outputs which give visibility to invisible layers present in the quotidian life, thus, adding a cultural impression to design and computation.

Each image reflects the point of view of a user along a path. There will be differences in colors and distortion on the output image (skin). Each skin will be unique and will reflect the singular point of view of the user's time, place and playfulness.

CitySkin also provides a mean to compare and experiment with different times of the day or year of a specific place, but also between different cities. Furthermore, this application allows recognizing patterns of time. Finally, the information presented in the final map, can give the user, a visual and immediate way to evaluate activities that relate to routine and movement. This information presentation benefit from a comparative evaluation, like for instance physical activities or by visualizing traffic jams. Cityskin is a tool to measure the quotidian qualitatively and quantitatively.

Capturing this life's time, that has periods perceived as blanks or non-places, is ultimately one the useful contribution of this application. Is this case, the challenge is to re-capture the perception of fleeting time, specifically showing variables that are not obvious to the user. Thus, add a sense of wonder or fun, to an often called draining, empty experience that is commuting, or even register layers of perception while travelling un/familiar places. Finally. CitySkin suggest to slow down, and embrace contemplation.

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