



“In search of Light”: Enhancing Touristic Recommender Services with Local Weather Data

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Abstract

Many destinations' economies strongly rely on tourism. Therefore, it is crucial to meet tourists' expectations, so they will return to the destination. The geographical formation of certain touristic islands often leads to local climates where it can be rainy and windy on one side of the island, whereas the other part is sunny. In this paper, we present a novel use for a network of sensors, *LightBeam*, a mobile location-based application aiming to improve the tourists' experience. The application focuses on providing real-time guidance for tourists seeking sunlight to maximize their holiday experience by suggesting the closest *points of interest* (POIs) to the user with the “best sunlight”. To achieve this, we implemented and installed a network of geospatial sensors. The data from the sensor network is combined with the current location of the users to provide recommendations. We report on the initial design and prototype of *LightBeam*.

Author Keywords

Weather application; Mobile Application; Tourism; User experience

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ACM Classification Keywords

H.5.2. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction & Motivation

New technologies and in particular mobile technologies have revolutionized the traditional model for tourism by allowing easy access to a variety of information about tourism destinations. A new type of tourist has emerged, one that uses and relies upon technology to have a more insightful experience in the place that they are visiting. However, many travel decisions are still made based upon weather conditions [9,11]. Many tourist destinations are well known for their good weather all year round. Nevertheless, weather often times can be unpredictable, especially in destinations with micro-climates [21] where it might be heavily raining in one location while another is sunny. Imagine a tourist from a northern European country in search of the sun; a lack of sunlight can ruin their holiday experience as seen in the work of Maddison [9]. Bad weather is considered to be an important factor that negatively influences a holiday experience.

Currently, most tourist applications simply inform of activities to embark on or deliver weather information based on forecasts. Tourists must research for activities they're interested in or POIs they wish to visit and then check the weather to figure out the best course of action for them while on vacation. Applications that provide all this information in one place are scarce. Even when the tourist goes through with all this preparation, current weather services in some locations, especially mountain or island destinations affected by microclimates, cannot deliver weather information at the granularity needed for the tourist.

Take the island of Madeira for example: It is situated in the Atlantic Ocean. It has a mild sub-tropical climate and a diverse landscape, with 50% of the island being above 700m (2295ft). This results in the rise of various microclimates within a microclimate. Doing a quick online research on Madeira, one will find articles on how Madeira's weather is unique [1,21,22]. Tourism takes a fundamental role in Madeira's economy. It represents 30% of the island's PIB [2]. Research has shown that Madeira tourists prefer outdoor activities. They continue to consider Madeira's weather as its most valuable asset [2,12]. Most of their morning and afternoon activities are performed outdoors and are therefore weather dependent. Due to Madeira's microclimate, tourists are sometimes forced to quickly re-adjust their plans. Therefore, it is not uncommon to find recommendations and reviews on certain locations making references to the weather [23].

Like in the case of Madeira, many economies strongly rely on tourism. Therefore, we believe it is important to provide real-time weather information to meet tourists' expectations, so they have the best experience possible and eventually return to the destination in the future [17]. The presented work contributes with the design of a novel mobile application focused on providing real-time guidance for tourists based on local sunlight conditions and with a unique use case for a network of sensors to enhance the tourism experience. The application's main goal is to suggest the closest POIs to the user with the "best sunlight". It is important to highlight that we defined the "best sunlight" as the amount of sunlight desired by a tourist to embark on her/his activities. For example a tourist who wants to enjoy a day at the beach would more likely prefer a high amount of sunlight while a tourist interested in

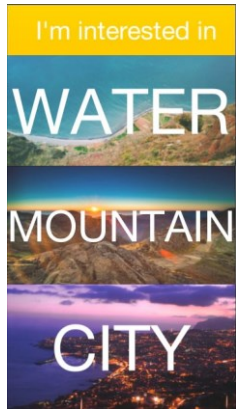


Figure 1 a) selection *LightBeam* Mobile Application Screenshot – POI type selection



Figure 1 b) *LightBeam* Mobile Application Screenshot – sunlight intensity

hiking or climbing could prefer a more cloudy sky. Therefore, we denote the location with the “best sunlight” as a location where the measured luminosity suits the tourist’s activity interests. Furthermore, the tourist’s wellbeing was a decisive factor for us; a place with a high UV intensity could be a potential health risk to her/him [5,10]. Because of that, we incorporate UV radiation measurements into our app’s algorithm, to take potential health implications into account, before offering recommendations. This will allow tourists to engage in the activities they came for while enjoying the optimal weather conditions. Our solution enables tourists to make an informed decision based on real-time sunlight data combined with location-based recommendations.

Related Work

Studies show that the weather and climate is one of the most influencing factors on tourists’ choices [9,11]. Moreover, it affects satisfaction and entices tourists to return to a destination [6]. Many touristic activities are weather sensitive [15] and often, when faced by adverse weather conditions, tourists have to rethink their planned activities. Therefore, knowing the course

of the weather allows for appropriate tactics to ensure that tourists have a good time. The amount of weather forecast information has grown; many mobile applications [24–27] make forecast information available, such as the temperature comfort index, the UV index, conditions of the sea and water temperatures. However, these are usually based on predictions instead of real-time data. The importance of having real-time weather information for travelers was studied in the work of Thakuria [16] to predict future speeds in a traveler’s route so that they can make

travel decisions relating to the weather. Recent work [3,7,18] has emphasized how weather information can influence the relevance of a POI to the user’s current context. Zhang proposed a personalized recommendation algorithm that takes the user’s context into account (like her/his preferences, friendships and geographic location) to provide tourists with more meaningful suggestions on POIs [20]. However and in agreement with Ylipulli’s work [19], we also believe that combining climate sensitive thinking with HCI methodologies is necessary when providing insightful touristic suggestions. Aligned with this approach, Smirnov [14] proposed a recommendation system for *tourist attraction information services*. It provides recommendations on which attractions to attend, based on the tourist’s preferences and the location’s context information, including weather forecasts.

So far, we can see that researchers have independently developed tourism recommendation systems as well as weather recommendation systems. However, the combination of both is still uncommon, especially for systems providing real-time recommendations. Inspired how climate, weather and in particular how sunlight influences the tourists’ enjoyment in their holidays, we aim to contribute with the design and implementation of a mobile application that recommends POIs to tourists, by combining their context and preferences with real-time sunlight data collected by a network of sensors placed throughout the destination.

LightBeam Application

The *LightBeam* application provides users with the possibility to find the closest POI with the “best-sunlight”. The user interface follows an advising-



Figure 1 c) *LightBeam* Mobile Application Screenshot – ordered list of POI



Figure 1 d) *LightBeam* Mobile Application Screenshot -

process which guides the user through different steps/screens to provide the contextual information required by the application. First, the level of sunlight that he/she prefers (Figure 1a). Second, the location for the type of activity he/she is interested in (e.g. hiking – Mountain; sailing – Water; Museum – City, etc., Figure 1b). Afterwards, the application retrieves the current sunlight, UV and temperature conditions from a network of sensor nodes spread around the destination’s POIs and shows the user a list of recommended POIs to visit (Figure 1c). This list is sorted based on a recommendation algorithm developed by us.

The algorithm takes several parameters into account: the POI distance, light intensity, UV irradiance and temperature. It then matches these parameters with the user’s context (location, activity interests and sunlight intensity previously chosen). If multiple locations present the exact same conditions in all the parameters, the algorithm recommends the closest POI to the user. The location with “the best sunlight”, in our approach, is a location with a light intensity that best suits the user’s activity interests, combined with the lowest UV irradiance.

Our goal with this application is to assist users seeking specific weather and sunlight conditions by enabling them to optimally use their vacation time in locations where the weather is unstable. For example: a rainy day in Funchal, Madeira’s capital might discourage visitors from going out to the beach in Funchal. However, if they would have access to real-time weather data from other cities/locations nearby with better weather conditions, it could help them to still enjoy a sunny day at the beach despite their original

plans being cancelled by the rain in Funchal, eventually adding some serendipity to their vacation; something often appreciated by certain types of tourists [8].

Prototype Implementation

We used the SenseBox toolkit [4] to build two local sensor nodes that are equipped with a light intensity sensor, a UV irradiance sensor and a temperature sensor (Figure 2). The data was streamed over Wi-Fi and uploaded to the OpenSenseMap [28] platform. This allowed us to retrieve the information into our mobile application through the OpenSenseMap API [29]. The current prototype was developed in Unity3D with Android OS as the target platform. Real-time measurement data from the sensor nodes was accessed through the same API (OpenSenseMap) using HTTP requests. A generic representation of the system is represented in Figure 3. The two sensor nodes were installed in two opposite locations of Madeira Island to enable us to test our recommendation algorithm which we describe in detail in the following paragraphs.

A location is defined by five attributes: distance, temperature, light, UVr and WeightSum. Based on the POI type chosen by the user, a list of locations is created, having its attributes initialized with the values returned by the OpenSenseMap. The attribute distance is calculated and converted into kilometers based on the coordinates latitude and longitude of both user and station positions taking into account the earth radius in miles. The WeightSum is initialized with zero. Then, for each location, the attributes’ weights are calculated, ranging from 1-3 according to their respective units and values. Table 1. shows an example of weights applied for each attribute. In this case the user has defined a preference for high sunlight intensity. For testing

Table 1 – Example of attributed weights for a user that prefers high sunlight intensity

Location attribute	Range	Weight
Distance (km)	dist ≤ 10	3
	20 ≥ dist < 10	2
	dist > 20	1
Temperature (deg)	36 < temp >= 25	3
	25 > temp > 18	2
	18 <= temp > 36	1
Light (lux)	Lux > 20000	3
	500 < lux < 20000	2
	lux <= 500	1
UV (16-bit)	uv ≤ 10	3
	10 < lux <= 50	2
	> 50	1

purposes, we defined that the best choice would be the shortest POI with the highest (but not too high) temperature and the lowest UV irradiance. The light intensity is customized by the user. Each location's WeightSum attribute is the sum of each location's weights. The list of locations is then ordered descending by the WeightSum attribute and displayed in the interface (Figure 1c). The POI with the highest WeightSum value is displayed first. It is important to emphasize that the weights were attributed heuristically just for testing and prototyping purposes. In the future work section, we mention how we intent to further optimize the recommendation algorithm to attain better results based on user contexts and preferences.

In addition, the *LightBeam* application is able to provide a short description of the POIs along with its location on Google Maps (Figure 1d).

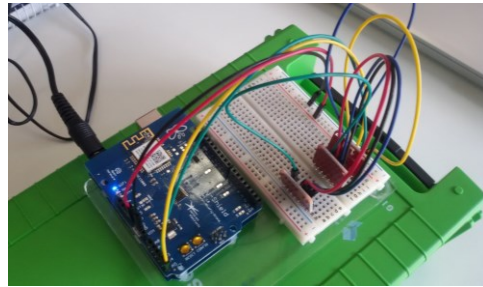


Figure 2: Mini-weather station Prototype using SenseBox:edu.

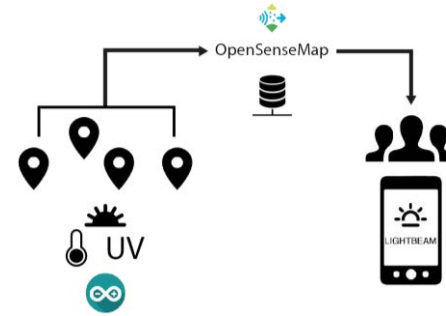


Figure 3: *LightBeam* overall system representation

Discussion

Our concept raises many challenges and further questions. First of all, to get our system of the ground and to be able to provide an actual benefit to tourists, we first need to expand and sustainably maintain [13] the network of sensor nodes; all the POIs around the island need to be included. Furthermore, the nodes' internet connectivity needs to be improved and extended. One possibility is to join an already existing infrastructure such as the one being developed by the Beanstalk research project [30]. Here a network of Wi-Fi routers could be enhanced with our sensor nodes. With the enhancement and expansion of the sensor nodes network and with the advances in cloud computing and real-time data processing, the *LightBeam* algorithm and overall solution would be substantially improved if integrated with a knowledge discovery module that would assist in the automatic and intelligent weights computation [31] based not only on both user context and preferences but also on other users' preferences and trends. A database in the cloud will have to be considered to support the system scalability.

Furthermore, the several hypothesis we made in this paper need to be validated. An evaluation needs to be carried out to study if our system actually proves to be more useful to tourists than forecast data - maybe a combination of the two data sources could be even more beneficial for our system. Moreover, the reliability of the sensor network needs to be studied. Can the sensor nodes provide accurate data over a prolonged period of time, in all kinds of weather conditions, without breaking or losing internet connectivity? Besides that, user studies should be conducted to analyze the usability- and user experience aspects of the app and the recommendation algorithm. Is the app usable? Are the recommendations useful to tourists and do they follow them? If evidence can be found that our system would have an impact on the decisions that tourists make, it would also be important to study the impact such a system would have on the local environment and economy. E.g. are tourists visiting more locations in the rural areas, because of the recommendations given?

Conclusions & Future work

We want to provide users with real-time environmental data to enable them to make optimal decisions that enhance their travel experiences. Our *LightBeam* solution may be helpful to tourists to meet their expectations while exploring outdoor POIs when travelling to new locations (this of course needs to be validated). Our concept combines the power of spatial data from a network of sensors with the user's personal context and environmental preferences to suggest locations with the "best sunlight". To achieve this, we have envisioned and implemented an algorithm that processes different sensor parameters (Light, UV and Temperature) along with the user's distance to the POI

and activity interests. We assigned weights to each of these parameters to determine the order in which the recommendation is presented to the user. While we still need to validate and evaluate our concepts we already think of future improvements to our system that could be twofold:

1. Widen the sensors' capabilities to measure data like air pressure (e.g. for POIs on mountains) or air pollution levels (e.g. in cities); providing even further real-time environmental information.
2. Adding features to the *LightBeam* application: The next development iteration could be implemented as a distributed service-oriented application [14] which would integrate POI popularities by including ratings from well-known social media platforms, like Trip-Advisor. We also would like to integrate volunteered geographical information (VGI), like Instagram photos. Furthermore, we would like to add customization features in the app's settings (e.g. one tourist could set her/his preferences so that the distance to the POIs doesn't matter, because he/she is travelling by car) and add more activity categories for users to choose from, allowing them to select the ones most interesting to them. This way the recommendation algorithm would work more personalized, which could lead to a better travel experience.

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