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Paper (Consumer Services)

Phorec: Context-Aware Photography Support System Based on Social Data Analysis

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Abstract: In the world of digital photography, it is widely known that general contexts including location, date, time, weather condition, composition, and camera setting, obviously affect quality of photos. In this paper, we analyzed the crowdsourced big data on the social network for photographers and extracted the rich photographic information in order to assist photographers to take beautiful photos. Our developed system is composed of server-side system and mobile application. The server-side system suggests good photos which are relevant to the contexts. The sophisticated iOS application was developed to collect the contexts and exhibit the result. The user's satisfaction in Phorec were measured through subjective evaluations. The result reflected that recommended photography settings are important and can fulfil user's desire.

Keywords: photography, social data analysis, mobile application, context-awareness

1. Introduction

The ubiquity of Digital Single Lens Reflect (DSLR) and Mirrorless camera is changing the world of photography recently. Not only professionals, but also amateurs who use these complicated cameras as hobbies or fashions carry them to everywhere they go. This phenomenon grows a large number of novice photographers. However, high capability camera requires some special knowledge and skills in order to maximize its potential and obtain good photographs. Such skills, for example, aperture controlling, light compensation, and composition (i.e., Rule of third [1]), are kinds of art that requires some experiences and cannot be acquired easily in short times.

We are living in the age of digital equipments. Photography was transformed from the traditional film to digital photography. Sophisticated support systems in the modern digital cameras simplify photography to be just one click. Saying that we almost need not to control anything on the camera. Auto exposure system calculates the appropriate aperture, shutter speed, ISO, and white balance for each light condition. Auto focus system finds the main object and points the focus on it automatically. These approaches are good but may not be enough for the serious shot. In some situations, controlling aperture manually awards more fascinating photos. **Figure 1** shows the result of small aperture bringing the beautiful ray of sunlight. Motion and mood can be expressed by different shutter speeds. High ISO can help us taking photos under the low-light condition, however, it gives us the undesirable noise. From these features and limitation of camera parameters, it becomes important for photographers to understand and know how to control them under various situations.

Apart from photographic knowledge and skills, the natural contexts, including location, time, season, and weather condition, are known as natural keys of landscape photography. At the same place, high quality photos can be taken from many positions. Some spots give you a good photo in the cloudy morning in spring, but some spots may be better for taking the photo of snowy sunset in winter as compared in **Fig. 2**. Because light condition is the significant factor, almost every landscape photos are dominated by the sunlight. Different directions of sunlight result in the various light density and shadow. As **Fig. 3** shows the different photos taken in the afternoon and dusk on the same day, dawn and dusk are proper for taking typical landscape photo because direction and color of the light is better than the overhead light of noon. However polarizing light in the middle of the day dramatically affects blue color of the sky behind objects, such as buildings and mountains. Accordingly, location, time of the day,

Fig. 1 Photos with the same light condition but different exposure setting. The left photo was taken with aperture f/5.6 while the right photo was taken with aperture f/16.

Fig. 2 Photos taken in different season.

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Fig. 3 Photos taken in different time of the same day.

day of the year and weather condition are very important factors that most experienced photographers always consider. Combining these contexts with camera settings and composition, it becomes very challenging for novice photographers to thoroughly find out the perfect combination. Although current digital cameras provide some sophisticated supports, such as auto-focus and auto-exposure system, which help users to control their camera easily, there is little or no support for user to know the appropriate location, timing, and framing for the good-composition photo.

The growth of photographers results in a bloom of photography community at the same time. People around the world upload and share their photos to online repositories. Those uploaded photos later receive comments and ratings from the community. This flow generates a learning from mistakes and examples strategy. We can roughly know the quality of a photo from its feedback and how to improve it from the related photos nearby. A high-rated photos explicitly teach us the appropriate composition and camera setting, on the other way, they implicitly inform the good location, time, season, and weather condition of those places. From this point of view, we can see that anyone can easily learn the photography through the fertile social network. However, this scenario is currently difficult in practice. There are few systems that provide corresponding photos from the given contexts.

Based on these observations, we propose a context-aware photography support system called *Phorec*. We utilize the meaningful information from a well-known online photo repository, Flickr [*1], combining with an online historical weather database in Weather Underground [*2]. Our system suggests special settings for taking beautiful photos on modern mobile devices equipped with various sensors, which can gather user contexts and GPS coordinates. Since there are many categories of photography and our system targets on not just photographers but tourists and general users as well, we focus our system on the "landscape photography." We assume that landscape photos can be discriminated by analyzing tags and photo Exif metadata, and the goodness of photo can be measured by examining online popularity and user feedback while using the system. Our major challenges addressing the problem of photo recommender system are as follows. 1) The system should be able to suggest the good photo based on the user's contextual information, such as location, time, and especially weather condition. 2) The system should guide the user to the best location for taking a similar photo to the recommended one. 3) The photos suggested in the system should be categorized as landscape photos.

The remaining chapters of this paper are organized as follows. Section 2 briefly reviews existing related works. Section 3 introduces our contribution in the photography support system including system architecture, data processing and user interfaces of the developed mobile application. Section 4 explains our evaluation of the system. Section 5 finally summarizes the content of this paper and discusses the future work.

[*1] www.flickr.com
[*2] www.wunderground.com

2. Related Works

With the growth of geo-tagged photography in online photo repositories, for example Flickr, many researchers make use of this meaningful data to achieve photography-related novelties. Many approaches attracted in interpreting semantics of photos. Reference [2] introduces several approaches, for example, spatial and spatio-temporal clusters, text analysis from title and tags, and content-based analysis, to analyze events and places from geo-tagged photo collections. Reference [3] describes location, interests and representative keyword of photo from tags and geo-information of photo. From the availability of Exif metadata, Ref. [4] uses exposure time and flash usage together with text analysis to classify the photos taken indoor and outdoor. Reference [5] helps us arrange photos in to album by using time stamp in the photos. Reference [6] analyzes textual and visual contents of photos and recommends photos based on user's preference from the topic driven and visual similarity.

For tourist supporting, Ref. [7] focuses on finding landmark of famous cities and recommends places to visit and things to do based on user's past travelling and experiences while Ref. [8] also recommends tourist attractions in famous cities but from the time aspect. Reference [9] generates 3D model of the location from a collection of photos online and navigates user to the places on mobile phone.

In the field of photography supporting, many researchers introduce systems for post-processing and also at the time user take photos. Qualitative evaluation of photos from art to computational aesthetic score was introduced in Ref. [10] by analyzing low-level image features. Reference [11] also attempts to score the beautifulness of photos and provides an automatic post-cropping and a retargeting photos system for optimizing the best composition. Reference [12] develops a photo recommender, directional assistance and framing assistance based on user's contexts. Those contexts are location, direction, date, time, and lighting condition. From our point of view, this system still lacks in analyzing weather condition, which is very important to the lighting condition, and there is no information about the optimal camera settings. By mining and image-processing on photos, Ref. [13] recommends optimal composition and exposure parameters corresponding to user's contexts. However we argue that supporting photographers to be able to capture good photos can be done by showing some example photos those are relevant to user's contexts with camera settings, rather than fixing the frame and camera settings of the smartphone's camera.

3. Photography Support System

Our proposed system aims to support users, not only photographers but also general users, while planning a trip or being at the place through a mobile application. We assume that relevant pho-

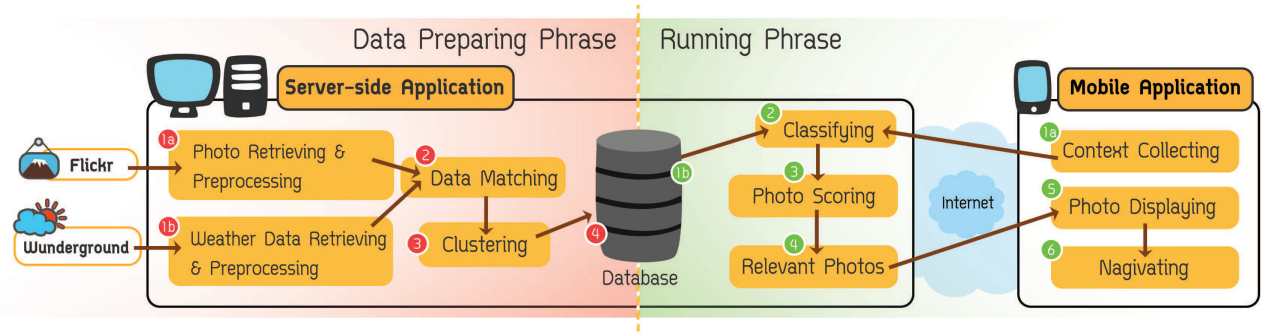


Fig. 4 System architecture of Phorec.

tos with camera parameters and context information can advise users about where and when they should go, how the appropriate camera setting should be, and what kind of photos they may get. This assumption does not mean that we encourage users to immitate or take photo in the same way as someone has already done, but we expect that users will get some information that can be shared in public, i.e., good location and timing, and get some ideas of controlling camera in each situation. Finally, as a learning by example basis, we believe that users will adapt the knowledge and information gathered from well-composed photos and find their own way to improve photography skill.

As an input, the system takes context information, context weights, and user's profile from a user. By comparing contexts information of prior-collected photos in database with user's contexts, filtering only relevant photos and scoring them by weighting score, the system outputs the relevant photos to the user through sophisticated interfaces. Because API provided by online photography repository and historical weather database have requesting limitations and we would like to realize feedback analysis, we divide the system into two parts, as shown in **Fig. 4**, *1) Phorec server* and *2) Phorec mobile application*. The server-side system takes responsibility in preprocessing photo and weather information to be ready for being used during the running phrase. The end-user mobile application is implemented for iOS devices (iPhone), to sense user's contexts, pass data to the server, and display the result to the user. Communication between two systems are done via the Internet through a web service provided by the developed server.

3.1 Phorec Server

In order to analyze a number of photos, we develop an automatic system for retrieving photo information from Flickr and storing these information in our database. Thanks to the Flickr API provided by Flickr, we can retrieve photo's Exif metadata, GPS coordinates, and social feedback of photos taken around the given GPS coordinates and coverage radius. We have collected about 100,000 photos taken around famous places in Osaka, Kyoto, and Nara in Japan. The actual amount of photos taken at each place is much more than this unless we focus on only photos that embed GPS coordinates in Exif metadata. Because Flickr allows user to tag the location of each photo when uploading to the server, the locations of post-tagged photos may not be the accurate taken locations. After collecting photos information from Flickr, we modify some information that has been saved in the inconsistence format, for example, the shutter speed "0.017 sec" is converted into "1/60." From the API provided by Weather Underground, we request the weather condition, for example, clear, heavy rain, mostly cloudy, etc., of the location at the time that each photo was taken and match it with the photo in our database.

During running phrase, server-side system provides a web service for front-end Phorec mobile application. It receives a request from a user with user's context information, including location, date, time, weather condition, and context weights. The location of user is processed firstly to find the nearby places and neighbor points of interest. The distance between user's location and photo's taken location is calculated by using Haversine formula [14]. Then the photos taken nearby user's location are scored with a vector representing photo's context information $V(location, date, time, weather\ condition)$. Score of location S_l is calculated by the distance between GPS coordinates of user and photo D_l normalized by comparing with the inputed maximum coverage radius r_m.

$$S_l = 1 - \frac{D_l}{r_m} \tag{1}$$

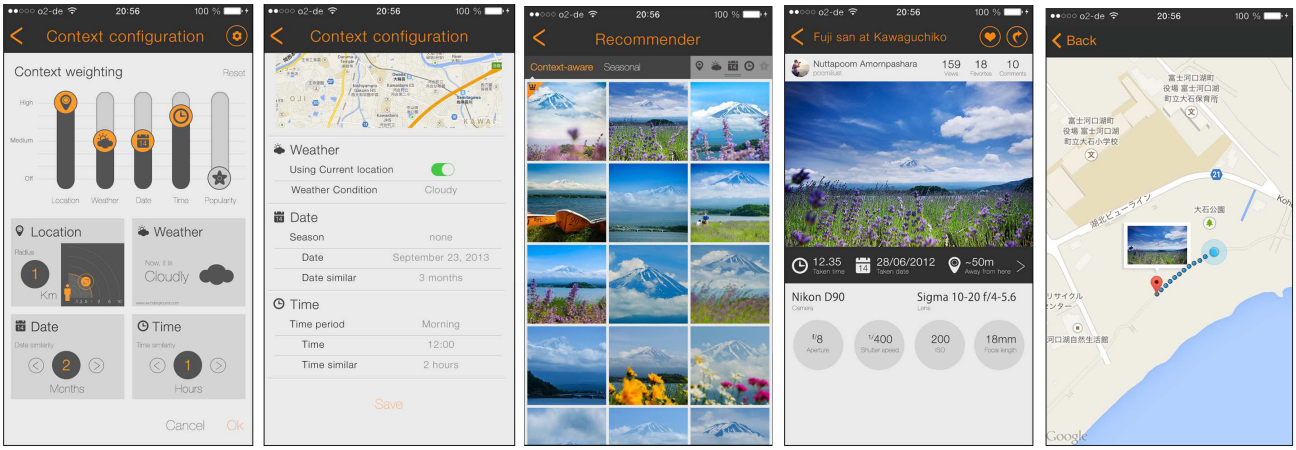
For the score of date S_d, we find the different day between user's actual date and photo's taken date D_d. If the difference between dates is within the user's defined similar date, the full score is given, otherwise normalized date difference will be given. For the time of a day, we calculate the score of time S_t by using the different hour between user's actual time and photo's taken time D_h in the same way as season score.

$$S_d = \begin{cases} 1 & D_d \le Similar\ date \\ 1 - \frac{D_d}{366} & D_d > Similar\ date \end{cases} \tag{2}$$

$$S_t = \begin{cases} 1 & D_h \le Similar\ hour \\ 1 - \frac{D_h}{1440} & D_h > Similar\ hour \end{cases} \tag{3}$$

From Weather Underground, weather condition is classified into several set. Based on the similarity of each condition, numerical representative is given as shown in **Table 1**. Finally we can calculate the score of weather condition S_w by comparing the converted numerical value of user W_u and photo W_p.

$$S_w = 1 - \left(\frac{|W_u - W_p|}{2.5} \right) \tag{4}$$



(a) Context Configuration for Recommender (b) Context Configuration for Photo Explorer (c) Photo List (d) Photo Viewer (e) Navigator

Fig. 5 User interface of Phorec mobile application.

Table 1 Numerical values of weather conditions.

Weather condition	Numerical value
Clear	1.0
Partly cloudy	2.0
Scattered clouds	2.1
Mostly cloudy	2.2
Haze	2.4
Rain shower	3.0
Light rain shower	3.1
Heavy rain shower	3.2
Light thunderstorms and rain	3.3
Thunderstorms	3.4
Heavy thunderstorms and rain	3.5

Lastly, the popularity score S_p can be computed by using user's feedback in Flickr (number of Favorites N_f and Views N_v) combining with user's feedback inside our system N_{sv}, which is collected from number of unique views. The popularity score is also normalized by the highest feedback among related photos. The popularity score is defined as:

$$S_p = \alpha \frac{N_f}{Max(N_f)} + \beta \frac{N_v}{Max(N_v)} + \gamma \frac{N_{sv}}{Max(N_{sv})} \quad (5)$$

where α is the weight for number of favourites, β is the weight for number of views, and γ is the weight for in-app views. Context weights from the user, including location w_l, date w_d, time w_t, weather w_w, and popularity w_p, is then used for final calculation of the score of each photo S_n. The top-n (roughly $n = 200$) photos are finally returned to the user as a result encoded in JSON format.

$$S_n = \frac{(w_l S_w + w_d S_d + w_t S_t + w_w S_w + w_p S_p)}{w_l + w_d + w_t + w_w + w_p} \quad (6)$$

3.2 Phorec Mobile Application

We developed the Phorec, an iOS application for iPhone that collects user's contexts and serves user a relevant photos with settings and navigation system. The application is composed of two minor systems; *Recommender* and *Photo Explorer*. Recommender system is designed for the scenario that a user is at the place and user's contexts can be directly collected from the actual surrounding. A user can briefly configure the context's parameters (location's coverage radius, similarity of date and time) and context's weights. On the other hand, Photo Explorer system provides a manual configuration for every context even if a user is not at the place. This system allows a user to explore photos taken at any place at any time for both planning and observing. The remaining parts of this application are Photo List, Photo viewer, and Navigator.

3.2.1 Context Configuration

Among several interfaces of Phorec iOS application, only Context Configuration provides two different interfaces for Context Configuration and for Photo Explorer system. **Figure 5** (a) shows the user interface of Context Configuration for Recommender system composed of context weights panel, which allows user to balance the weights among the contexts by using a sliding bar. The lower context configuration field allows user to set the location's coverage radius and similarity of date and hour. The other necessary parameters are automatically collected from the device, including GPS coordinates, actual date and time, and the retrieved current weather condition from Weather Underground. For the Photo Explorer system, as shown in Fig. 5 (b), user can set every parameter of the contexts, including location and the coverage radius, date, time, and weather condition. Similar to the Recommender system's Context Configuration, the context weights panel is also available.

3.2.2 Photo List

Contexts information with its weighting parameters are collected from the Context Configuration part, encoded into JSON format and sent to the Phorec server through the Internet. After analysis, Photo List interface, as shown in Fig. 5 (c) handles the received JSON formatted photos list from the server and retrieves thumbnail photos from the URLs given in the list. Photos thumbnails are shown in grid view and arranged based on its score in descending order. This Interface informs user of the good photos that have been taken nearby under the similar or desired contexts. Each photo's information will be piggybacked to the Photo Viewer.

3.2.3 Photo Viewer

After user chooses a certain photo from Photo List, a feedback will be counted on the server. This feedback represents the in-

terestingness of this photo. Figure 5 (d) shows that camera's setting and context information are neatly displayed under the large-sized photo. From this meaningful information, users can learn how to handle their equipments in a similar situation. Moreover, users will know where and when they should go in order to take this kind of photo. The distance of photos' taken position from user's current location is calculated and shown on a button for Navigator.

3.2.4 Navigator

To guide user, we develop a Navigator that uses the Google Maps to show the spot where the photo was taken and user's current location as shown in Fig. 5 (e). The optimal route to access to the spot is also available by overlaying it on the map.

4. Evaluation

Since the goal of this system is to provide the important information for taking photo, including location, day of the year, time of the day, weather condition, and camera setting, we performed a subjective evaluation to verify whether these kinds of information are important and useful for photographers. The field-interview took place at Yoshino mountain, Nara, Japan on April 10, 2014. In total 26 participants ranging in age from early 20 to 74 (40 in average) were asked about their photography background and perspective of important information in photography. From the survey about expertise in photography, **Fig. 7**. shows the number of participants claiming themselves as amateur, intermediate, and professional. The variety of experience in photography by year is shown in **Fig. 8**. This information of expertise and experience explicitly informs us about their understanding in the photography settings. However, most of them claimed that they were intermediate even if they had experience in photography more than ten years. Among them, only one participant, who is photography teacher, rated himself as a professional.

The participants were then given a well-composed photo of panoramic view of Yoshino mountain taken by Augustin Rafael Reyes [*3] during the full-bloom of cherry blossom in the afternoon of foggy day as shown in **Fig. 6**. About 85 percent of them got interested and wanted to take this kind of photo by themselves. The settings including location, date, time, weather condition, and camera's parameters of that photo were shown to the participants with two questions; *1. Is this information useful?* and *2. Which information is important when taking or planning to take photos?*

Another field-experiment was done to verify that Phorec meets user's needs and works well in the real situation. We conducted the experiment in three different places in Osaka, Japan, including Mino waterfall, Osaka castle, and Sakai-Senboku industry area. From the photos in social network, we found that many photographers have been to these places and taken photos in different contexts. Eight subjects ranging from 22 to 48 years old participated in the experiment. Six of the participants claimed themselves as amateurs, two of them are intermediate and professional, respectively. They were asked to take photos by themselves before comparing the result with other photos taken after using Phorec. At the end of the experiment, we asked participants whether Phorec helps them take better photos and works well.

[*3] https://www.flickr.com/photos/agustinrafaelreyes/8141650694/

Fig. 6 Well-composed photo in Yoshino.

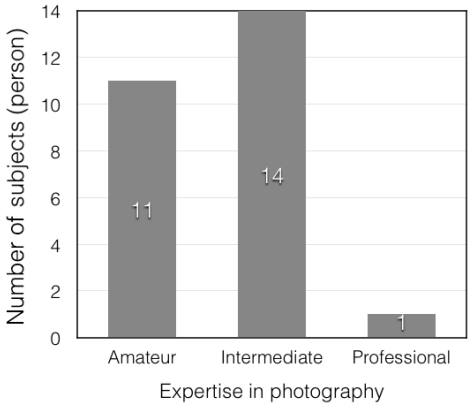


Fig. 7 Expertise in photography of participants.

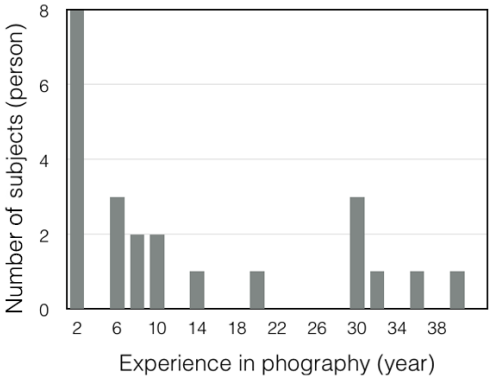


Fig. 8 Experience in photography of participants.

4.1 Usefulness of Contexts and Camera Setting of Photos

After we had shown the well-composed photo of the place where this experiment was taken with its settings, the participants was asked whether these kinds of information are useful for them. The result, as shown in **Fig. 9**, reflects that these kinds of information are very useful for most of them. As we had expect, 90 percent of amateur photographers, which is our target for this system, had a very high positive impression for this information. This fact shows that our system is likely to be a useful tool for beginner photographers. On the other hand, only 64 percent of intermediate photographers rated this the useful information. Some of them gave a reason for this decision that chances will bring them good photos instead. We believe that intermediate photographers may be able to know these information by them-

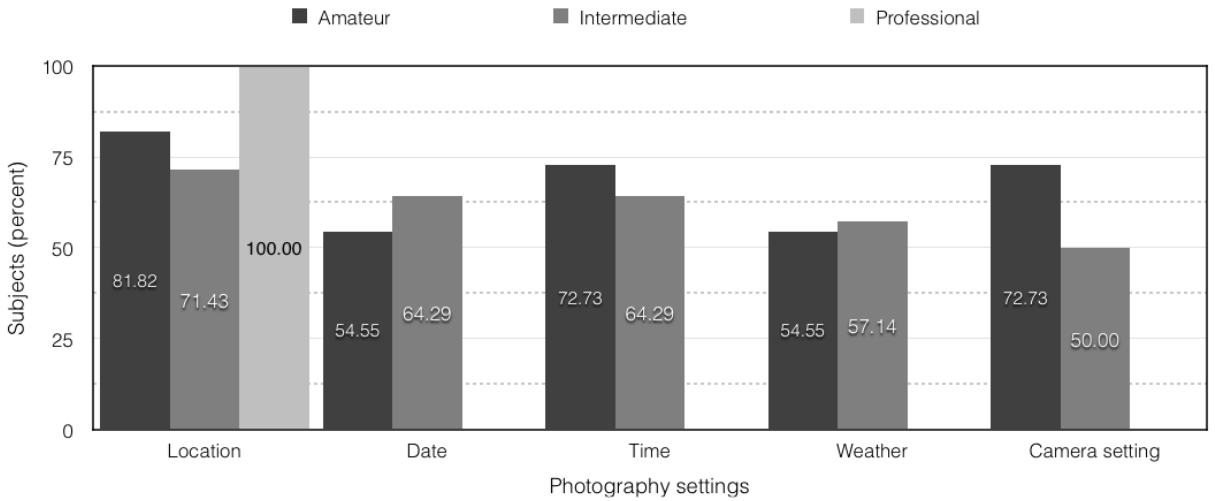


Fig. 10 Result of the important photography settings.

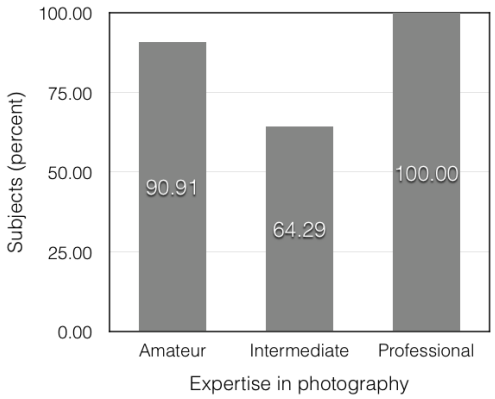


Fig. 9 Result of the usefulness of the system providing photography settings.

selves or from some other sources.

4.2 Importance of Photography Settings

From a list of photography settings, including location, date, time, weather, and camera setting, we asked participants to choose which information is important for them when taking photo or planning to take photo. Resulting from this trial in overall aspect, it turned out that location is the most important factor followed by time and equal date and camera setting. The least but still higher than half of participants took weather into account of photography. It is interesting that for amateur photographers, as shown in **Fig. 10**, time and camera setting turn to be important for them while date and time got more significant than camera setting for intermediates. From our point of view, we believe that amateur photographers want to know the fine controlling in different conditions but intermediates have enough experiences and skills so they might not need this data.

For the time, we did not expect that time would be dramatically more important than date and weather information for beginners. We thought that this result may be caused by the ambiguous meaning of the questionary. Because we divide our interviewers into four groups, each of the interviewers may diversely explained the meaning of each question so that participants may have misunderstood our intention. In terms of weather, especially for amateur photographers, they may not have understood how importance of weather that result in different condition of sunlight and sky. Inversely, they may think that clear day without rain or snow is the best condition for taking photo. However, this trial can roughly infer that all of these information is important for taking photo among levels of photographers.

4.3 Phorec in Real Situation

Figure 11 shows a map of the areas where this experiment took place. Mino waterfall and Osaka castle are two famous places and widely known among photographers while Sakai-Senboku industry area is only famous among industrial photographers. To access Mino waterfall, there is a trail along Mino river that has several spots for taking photos. Not only the characteristic of location but also the scenery of waterfall and river, that requires some special settings, makes this place special. Osaka castle is surrounded by Osaka castle park which covers an area of one square kilometer. Since there are several gardens, ponds and good spots for taking photos of the Osaka castle around the park, this place is considered to be appropriate to prove the importance of contexts. Sakai-Senboku industry area is a large area close to the Osaka bay, there are a number of oil refineries and factories. In this area, travelling from one spot to another spot could not be done by walk, so the location is the most important context needed to be considered. Accordingly we expect that Phorec can be proved that it is a good tool for photographers to find the good locations and context in the selected places.

In the beginning of the experiment at each place, we asked our participants to take several photos by themselves. Then devices installing Phorec were given to them. After a short introduction to Phorec, we asked them to use this application and take photos again. Finally, we ask them to rate their impression in photos taken after using Phorec compared to photos taken before and their satisfaction in Phorec. **Figure 12** displays atmosphere of the experiment at Mino waterfall and Osaka castle. Photos taken by the same user at Osaka castle before and after using Phorec in **Fig. 13** show that the user can find a better place to take photos. From the total rating of 5, they could impress their photos taken after using Phorec and satisfied in Phorec with average rating of

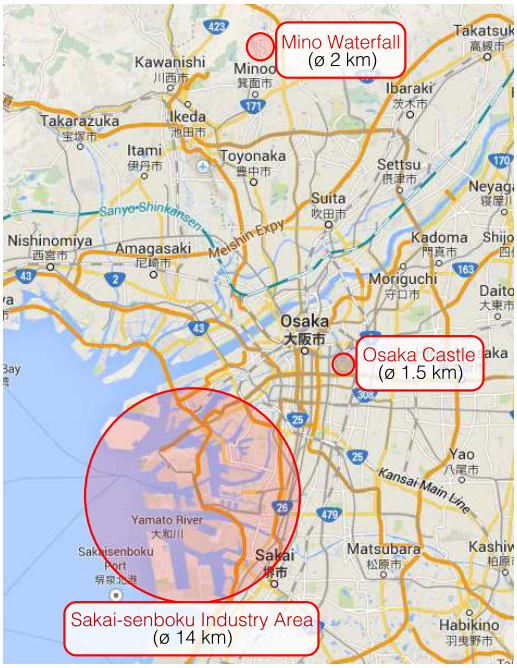


Fig. 11 Map showing the areas where the second experiment took place.

Fig. 12 Atmosphere of the experiment at Mino Waterfall and Osaka castle.

Fig. 13 Photo taken by a user before and after using Phorec.

4.63 and 4.50, respectively. This result reflects that Phorec can work well in the real situation and help user take better photos.

5. Conclusion

We have proposed the Phorec, the context-aware photography support system that provides good photos corresponding to user's context with settings information. Aim of this system is to explicitly inform the good photos taken around users and how to control the camera in each context and implicitly give user the important photography settings, including location, date, time, and weather condition for taking photo at each place. We expect that users will be able to improve their skill by learning from professional's examples and plan their travelling with good location and good timing. The result from the field-experiments of various expertise of photographers infers that photography settings including location, date, time, weather condition, and camera setting are important factors in photography, the system bringing these information is useful for most of them, especially amateur photographers when both planning and taking photo, and Phorec works well in the real situation and help user take better photos.

To improve this system and achieve our aims, we will focus on the classification of photos. Saying that we have an attempt to distinguish landscape photos from the messy collection of photos. Moreover, to be able to implicitly inform user of the good location of each place, we will perform another classification for photos in order to find the famous spot of each place among photographers with the optimal settings.

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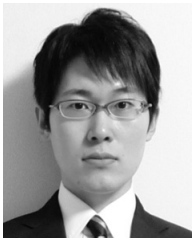

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