



# 3DIM: An Interactive 3D Map to Visualize Geo-Spatial Data in Mobile Devices

Ragaad AlTarawneh, Carl S. Marshall, Selvakumar Panneer,  
Cindy K. Chung

Intel Labs, Hillsboro, OR, USA

{`ragaad.altarawneh, carl.s.marshall,`  
`selvakumar.panneer, cindy.k.chung`}@intel.com

**Abstract.** We introduce an interactive 3D mobile-based map interface to visualize users' activities on Flickr. We designed the interface to handle limitations of smart devices' screen sizes by utilizing the new advancements in the performance domain of these devices, like relying more on GPU in rendering or producing high resolution pictures in real time. We compare the Flickr 2D map and the 3D interactive map of our app when they are rendered in smart devices. Our approach helps users keep the context of the picture and its geo-location without having to open a new view to explore the pictures and to get more details. We conducted a brief evaluation study where users preferred our proposed 3D interactive map compared to the 2D map, mainly due to the free rotation and the natural interaction techniques offered by our approach.

## 1 Introduction

Smart mobile devices (i.e., smartphones or tablets in our context) are now used for achieving many daily life routine tasks. Accordingly, their usage has increased dramatically over the last few years. However, many factors (such as limited screens sizes, new interaction styles, mobility, etc.) compared to desktop computing environments make it a big challenge to visualize big data on these smart mobile devices [1, 2, 3, 4]. Furthermore, handling and processing of various and possibly huge amounts of data (especially in the form of pictures) on these smart mobile devices is a growing challenge [2, 4].

In this regard, an interesting research question is how to adapt the visualization of big data into these mobile devices that on one hand support relatively limited capabilities (like screen size or battery life), while on the other hand, they support rich and natural interaction styles (e.g., multi-touch gestures). There have been many suggested optimization techniques to increase the battery life. However, we argue that the focus needs to shift towards using the Graphics Processing Unit (GPU) in the rendering phase rather than the standard Central Processing Unit (CPU). This would enable

developers to design their frameworks to utilize the parallel nature of GPUs, which would increase rendering speed and visualization performance dramatically.

With the evolution of current smart mobile devices more and more data are collected and stored, which open doors for new use cases and applications. For example, many social media tools enable users to share their data, pictures, or events. Facebook, Flickr and Instagram are few examples of heavily used platforms that offer these capabilities in real time. Due to the heavy usage of these platforms, they accumulate relatively big data over time. So, one challenge with such big data is how to summarize and present feature-rich data sets so that users/vendors can discover insights about their data more efficiently and effectively.

In this paper, we describe an interactive 3D mobile-based map interface that enables users of social media tools (Flickr<sup>1</sup> is a case study in our work) on smart devices to trace the most recent activities in the underlying social network. We describe the development of a picture-rich social media API viewer for the investigation of cultural trends of geo-tagged, user-generated pictures. We showcase the potential insights that could be gained from cross-cultural assessments in big data visualizations.

Finally, given the rich features in mixed media, we describe the advantages and limitations of the 3D interactive map visualization compared to the traditional 2D visualization on mobile devices. Our app allows real-time keyword queries of social media (i.e., Flickr in our case) and visualizes the pictures based on their geo-location tags. Users can interactively explore the 3D world to discover likeness or differences in trends of keywords across various regions. Comparing pictures of a keyword provides an immediate visual comparison of the term's popularity, as well as the relative conditions and behaviours associated with the term across regions.

The remainder of the paper is structured as follows: In Section 2, we describe our approach of visualizing the relations regarding the social media events and their geo locations. In Section 3, we discuss the result of a pilot study with 3 experts and we provide a comparison between the 2D map visualization and the 3D map visualization on mobile devices based on those experts feedback. In Section 4, we present the conducted user evaluation study and the overall results. Finally, we present our conclusions in Section 5.

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<sup>1</sup> <https://www.flickr.com/>

## 2 Visualizing the Relations between Social Media Events and their Geo-locations

The very concept of designing a visual interface targeting big data in mobile platforms directly triggers the scalability issue [4], as it is required to scale up or down the visual interface according to the underlying device size. At the same time, it is quite a challenge to keep the intuitiveness of the design regarding the clarity, readability and interaction styles provided by such interfaces [3].

In this paper, we tackle the problem of designing an interface that encodes the relations between posts on social media (i.e., Flickr in our case) with their geo-locations. Although this problem has been tackled in Desktop platforms and for large screen sizes, relatively few studies have addressed the problem from the perspective of mobile devices' interfaces.

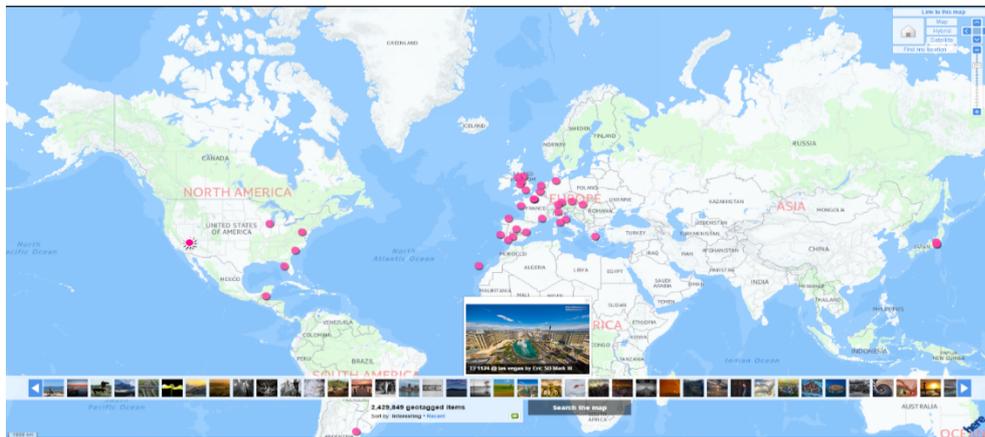


Figure 1: 2D Flickr map to show the pictures distribution over the world map, <https://www.flickr.com/>

The Flickr platform currently provides a 2D map interface as shown in Fig. 1. This interface works smoothly over desktop platforms, which are supported by a mouse interaction technique and relatively large-sized displays. Through Flickr's website, users can query publicly available Flickr's picture database with a search term, and obtain a 2D interactive map with dots to represent where relevant (defined by Flickr) pictures originated. The pictures are represented in a horizontal line at the bottom of this interactive map (see Fig. 1). Clicking on a particular dot on the map highlights the corresponding picture with caption at the bottom of the screen. Double-clicking takes the user to a full screen of the picture with picture owner information, caption, comments, likes, etc. The back button returns the user to the larger map. The pictures at the bottom horizontal bar of the screen can also be clicked, which results in highlighting of the corresponding dot on the map. Users can also

scroll the horizontal picture bar to discover a new set of pictures appearing in different geographical regions.

The main concern is the scalability and the readability of such a visualization on mobile devices that have relatively small screen sizes. To tackle this concern, we propose to replace the 2D world map with a 3D map representing the globe. In this case, the globe is rendered as a sphere textured with the world map; therefore, the cost of such visualization is not complex compared to the 2D map according to the GPU's rendering of it. This representation also offers a free rotation interaction style, where users can explore or rotate the globe using the swipe gesture interaction technique. We call this visualization the 3D Interactive Map (3DIM).

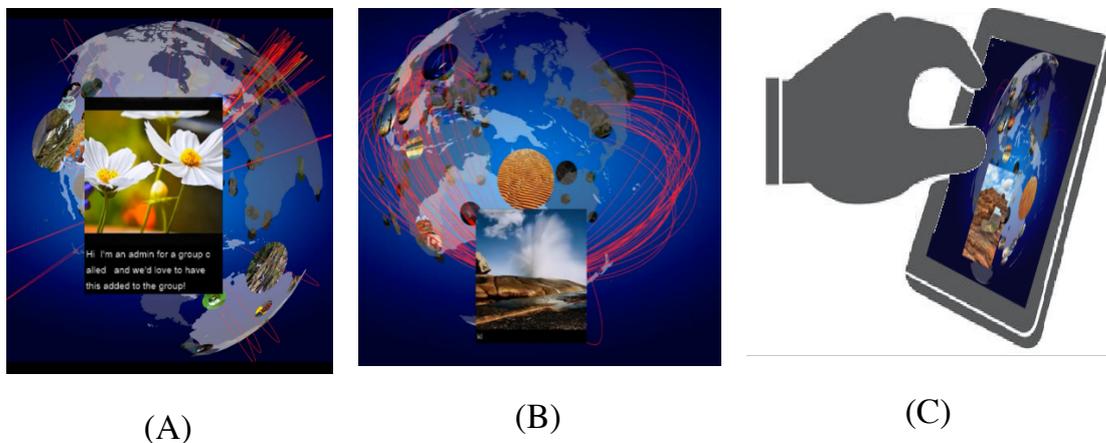


Figure 2: The 3D Interactive Map (3DIM) interface shows the relations between pictures corresponding to a key word search, and their geo-locations over the globe. (A) Shows the selected picture and aligns it with its location (in the United States), in addition to its caption. (B) Shows the other places that shared this picture's key-word using the color-coded lines. (C) Illustrates the idea of applying the 3DIM in mobile devices.

Our 3DIM approach provides an interface to visualize the relations between social media events and their geographical sources (see Fig. 2). The concept is very similar to the one provided by the Flickr 2D map visualization, where a user can query the database with search terms or click pictures to find their locations on the map. However, in our case, pictures from the search results are shown as discs on the geo-locations from which they originated, so that the point of the origin is immediately apparent with the most relevant visible pictures as defined by Flickr. The sizes of the discs represent the number of pictures from that particular region. This 3D effect allows for an immediate grasp of the popularity of a picture.

The 3D view of the pictures allows regions of the pictures to be visible while subtly showing picture locations that would be occluded by the world. This presentation invites users to discover data trends by exploring world. By

clicking a picture disc, the user can see the caption of the picture. In addition, the comments of the picture become visible through color-coded lines that arch around the globe to the comment. Users can rotate through all the comments of a particular picture (see Fig. 2).

### 3 2D vs. 3D Map Visualization on Mobile Devices

We performed an initial pilot study with three experts with a visualization and interaction design background, in which we instructed them to explore both interfaces, i.e., the Flickr 2D map interface and our 3D map interface, on a windows based mobile device.

#### 3.1 The 2D Interactive Map

As our experts tested the 2D map representation provided by Flickr on a smart device display, we observed the following:

The 2D world map was rendered over the whole display, which made it difficult to read as the map size was reduced due to the display size. The dots that represented the origins of the searched pictures were very small, which required additional interaction techniques to explore them properly. Also, the number of steps that were required to navigate through the picture database and to link them with their actual locations was relatively high; users had to identify the location through panning and swiping gestures followed by zooming in/out using the tapping/pinching gestures according to the location on the map. This process could lead to losing the context or the link between the selected picture and its location due to the change in the angle view.

#### 3.2 The 3D Interactive Map

As our experts tested our interactive 3D map interface on a smart device, we observed the following:

The experts were able to interact with the interface naturally through the swipe gesture that was used to rotate the globe as well as to rotate the pictures surrounding the globe. Those pictures were distributed based on their original geo-locations. Tapping on a picture of interest increased the selected picture's size in order to show further details. In this case, the globe was rendered in the background. This enabled the experts to link between pictures and their sources without losing the context. The interface also showed the set of links between a selected picture and the locations where users in those locations also shared the same picture. In this regard, we didn't notice any occlusion

resulting from the 3D effect, as the globe was rendered in transparent fashion when a picture was selected. We did not test the rotation facility using the accelerometer sensor facility.

### 3.3 Discussions

Upon comparing the Flickr's 2D visualization and our 3D map visualization, we noticed some immediately apparent differences, e.g., the representation of query results across geographical locations or the differences in construal for each query. Some examples of queries that were run to compare the 2D and 3D visualizations include:

- *Cat*: A popular focus on the social media, the “cat” query produced a large number of pictures across the world. It was observed that there are relatively larger cats (e.g., lions, cheetahs, etc.) in the open wild in Africa while relatively more domestic cats in other areas of the world. This fact was instantly more apparent on the 3D map compared to the 2D map.
- *Nature*: Vegetation and landscapes naturally vary by geographical conditions and this was apparent in both the 2D map and the 3D map. However, the experience of the climate and vegetation continuity and differences across regions were more immediately apparent in the 3D version.

From our experience, we observed that using the 3D map on mobile devices saves more space compared to the 2D map that expands horizontally and vertically over the device display. Users have more freedom and more intuitive interaction styles due to the free rotation interaction of the 3D map. However, the 3D map visualization was designed to show extra data only on demand, unlike the 2D map. For example, in the 3D map, the selected picture was shown and enlarged only compared to the other pictures upon user selection. Further, once the selected picture was enlarged it sometimes occluded the background, which hindered the readability or ability to detect relations between the selected picture and the other places that shared this particular picture.

## 4 The User Evaluation Study

We conducted an explorative user evaluation study, in which we invited 12 users explore and comment on both map visualizations, i.e., the 2D map visualization by Flickr and our 3D map visualization. All participants had a computer science background. Half of the participants were females, and their

ages ranged from 23 to 56 years. Users were selected randomly and were encouraged to participate in the study freely and voluntarily.

At the start of the experiment, an introduction to both platforms was given to each participant [by voice/experimenter/online?]. Half of the participants were randomly assigned to start with the Flickr 2D map visualization and then our 3D map visualization, while the other half did it in the reverse order. Both visualizations were rendered on a Windows-based tablet. Users were briefly introduced to how to use both apps and shown what their interesting features are. Then, they were given 5 to 10 minutes to play with both maps and to explore the features by themselves. After this, we asked them to give us their feedback through a closed-ended questionnaire form.

Figure 3 shows users' feedback and their preferences that we gathered from the given set of questionnaires. From the results, we can see that both map representations have the same number of votes, i.e., 6 votes for each, when users were asked which map they would like to use in the future. Results indicate that users found the 3D map visualization more intuitive, as it requires fewer interaction steps compared to the 2D map. Moreover, users found that the 2D map visualization was more readable and used the space more efficiently. However, this might be because the test was done on a tablet device. This feedback could be different in the case of using a smartphone with smaller screen.

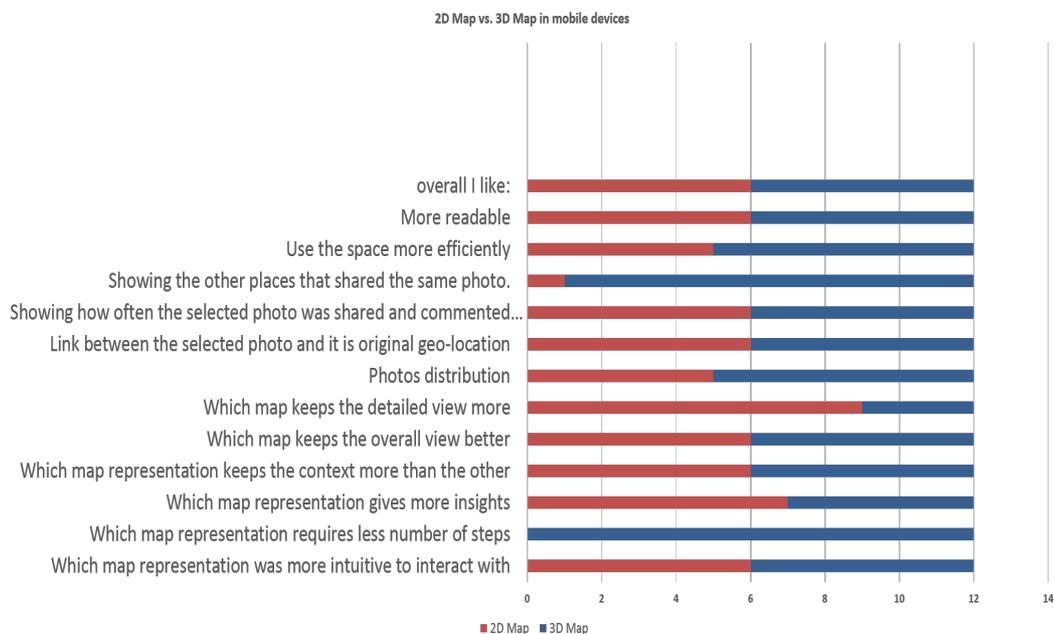


Figure 3: Overall results showing users feedback upon using 2D map and 3D map.

## 5 Conclusion

We presented our approach of visualizing 3D geo-spatial data on smart mobile devices. More specifically, we visualized Flickr pictures across their geo-location origins. For this, we proposed using a 3D map instead of the 2D map that has already been developed by Flickr. Our interactive 3D map utilizes the space on limited mobile screens more efficiently compared to the 2D map and enhances the grasp of the pictures' geo-distribution faster and clearer.

We compared the Flickr 2D map visualization and our 3D interactive map using mobile devices and compared the interaction steps that users needed to query some aspects on the visualizations. In summary, differences in cultural construal of concepts were more immediately apparent and more information was conveyed through the 3D effects without overwhelming the user. The 2D visualization required more interaction steps to dig deeper into the data although the general locations in which a search term was located or where it simply did not exist were more immediately apparent.

In future work, we will consider the users' feedback in optimizing our 3DIM map App. Moreover, we will investigate how to allow users to interact with this App utilizing multi-touch schemes provided by tablet devices.

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