Interfacing Real-Time Ozone Information

Ilyas Uyanik
Computational Physiology Lab
University of Houston
Houston, TX
iuyanik@uh.edu

Dan Price
Honors College
University of Houston
Houston, TX
dr.dan.price@gmail.com

Panagiotis Tsiamyrtzis
Department of Statistics
Athens University of
Economics and Business
Athens, Greece
pt@aueb.gr

Ioannis Pavlidis
Computational Physiology Lab
University of Houston
Houston, TX
ipavlidis@uh.edu

ABSTRACT

In this paper we report an interesting case of disagreement, within a design team and the user base, about how to interface real-time ozone information in a mobile app. High levels of ozone are harmful to health. They are the result of pollution under certain environmental conditions. Until recently only a categorical qualitative description was possible for an entire metropolitan area. With the proliferation of environmental sensor networks installed by the federal and local governments, real-time quantitative and localized ozone information has become available. Although this is fundamentally a different type of information with respect to the legacy one, stakeholders appear split when it comes to changing the interfacing scheme. It is a powerful example of the hold of tradition and the dilemmas it precipitates in design. It also opens the discussion about interfacing newly-minted real-time spatio-temporal information for a wide range of pollutants and irritants (from particulates to pollen).

Categories and Subject Descriptors

H.5.m. [**Information Interfaces and Presentation (e.g. HCI)**]: Miscellaneous

General Terms

Design, Measurement, Standardization

Keywords

Ozone mapping, real-time pollutant visualization, mobile weather app, visual metaphor, design dilemma

MAPINTERACT '13:, November 05 - 08 2013, Orlando, FL, USA
Copyright 2013 ACM 978-1-4503-2536-3/13/11 ...$15.00
http://dx.doi.org/10.1145/2534931.2534939.

1. INTRODUCTION

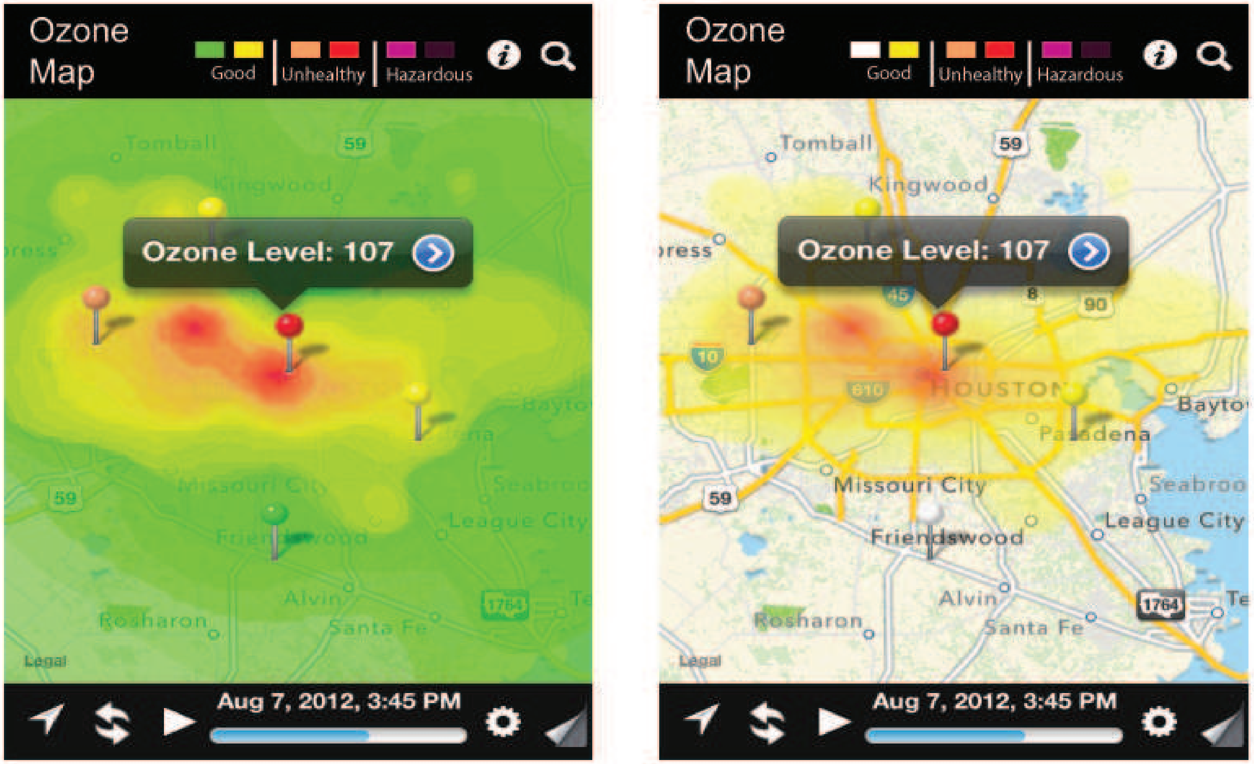
There has been proliferation of lifestyle weather reports ranging from air quality reports to allergy reports. Up to now such reporting has been categorical and qualitative; for example, 'Ozone levels today are high - Ozone Alert', accompanied by a red flag symbol. With the proliferation of specialty sensors in metropolitan areas and the development of interpolation algorithms, real-time quantitative pollutant information across space has become feasible [3][1]. Such detailed and live information enables people to plan their localized outdoor activities with far greater freedom. The first smartphone apps that wrap this information in mobile interfaces have appeared in the App Store and other portals.

There are fundamental questions about how to represent this newly minted data in order to facilitate communication and user interaction. Users as well as local agencies and environmental scientists (the producers of this information), come with their own preconceptions putting the designers in a conundrum. Poorly conceived and often conflicting interfaces undercut the usefulness and potential of these applications. The problem is exacerbated by the small display factor in mobile devices. Things look especially bleak if one considers the future integration of the various lifestyle weather reports in a composite mapping interface or in other relevant apps (e.g., physical activity apps). Adopting competing design philosophies, such integrated apps would pose usability challenges.

Here we present our initial experience in developing an iPhone app for reporting the spatio-temporal evolution of ozone clouds in the Houston metropolitan area - one of the first in the United States with a distributed network of environmental sensors. This experience does not only involve the overall app design and its evaluation, but also the resolution of disagreements between the app developers and the data producers of this project.

2. APP DESIGN

The purpose of our *OzoneMap* app is to communicate the ozone cloud movement in the Houston area for the last two hours (the app is freely available via the App Store). Ozone in high concentrations is a harmful pollutant and physical activity is highly discouraged in its presence [2]. Please note a number of characteristic factors that define the transitional



a b

Figure 1: OzoneMap app: a, Flag style skin, where safe ozone levels are colored green on the map. b, Radar style skin, where safe ozone levels are not colored at all on the map and the remaining colors have higher transparency.

and critical character of this and other similar apps:

1. It is unlikely that such apps will remain stand-alone for very long. Ozone levels constitute man-made weather and naturally belong to weather apps, as part of their lifestyle map section. Real-time ozone mapping can also be linked to physical activity apps (walking, running, and biking), as this information mostly concerns users who are physically active outdoors.

2. These apps provide information for specific metropolitan areas that have acute ozone problems (e.g., Los Angeles and Houston) and already have an ozone sensor network in place. As the infrastructure is being developed in other metropolitan areas, such information will become commonplace for cities across the United States and the world.

3. Right now there is emphasis on ozone, but soon information about other environmental pollutants (e.g., particulates) will become available.

4. These apps are not directly predictive. They let the user know how the ozone cloud has been developing the last couple of hours, leaving her/him to guess what is going to happen next. This renders information clarity doubly important.

We adopted a bare bones app design borrowing familiar user interface elements from other weather apps. The targeted user is an outdoor runner or simply a person who wants to plan her/his walking trip to the local grocery store. S/he needs an answer to a simple question: 'Should I do it right now or not?' Obviously, s/he expects to receive this answer fast and in as unambiguous terms as possible. Hence, by definition the app does not warranty long user visits, where extensive options and features might have been useful. In fact, we expect the average visit to last a few seconds.

Like with most weather related information, it makes sense to overlay ozone annotation on a map. For this reason we incorporated Apple Maps in our application. The app's opening screen is the map of the user's surrounding region (as determined by the phone's GPS reading), with a default pin at her/his position communicating the current ozone level (Figure 1). The user may add more pins by tapping specific points on the map. At the bottom of the screen the user can tap on the play icon to visualize the ozone cloud movement the last two hours. At the top of the screen there is a color map that helps the user interpreting the health impact of the evolving ozone clouds. The user can select the type of map (standard, satellite, or hybrid) and can search for a specific address to refocus the displayed map - both typical features in map applications.

The major interface issue at stake is the color scheme for communicating the evolution of ozone levels on the displayed map. The map covers $\sim 90\%$ of the application's real estate and obviously the superimposed color annotation for ozone levels greatly affects the way the user perceives information and interacts with it.

Two schools of thought formed early within the project team across disciplinary lines (environmental scientists versus computer scientists): **a.** Keep the legacy color mapping favored by environmental agencies, where green represents safe levels of ozone, yellow represents marginal levels, and hues of red represent unsafe levels. **b.** Replace the green color with clear coat while keeping everything else the same. The main argument for the first thesis was conformity to the established scheme of reporting environmental events - every event (safe or unsafe) needs to be flagged. An event that is not clearly flagged may be open to misinterpretation and subsequent litigation. The main argument for the second thesis was improved usability. Most of the time ozone levels are safe, even in problematic metropolitan areas. This means that under the legacy scheme the map will be covered nearly all the time with green color, reducing legibility. This is especially worrisome for future uses of this technology in apps for runners, who make heavy use of map information.

The legacy color annotation scheme for ozone levels was concocted in an era that only static, scalar information was available for a metropolitan area (e.g., normal ozone levels for Houston on October 24, 2002). In this case a single color flag for an entire region, which was valid for a day or more, was highly appropriate. There was no need to superimpose this uniform information on a map - it was typically accompanying a textual description as a side flag.

Things are quite different with the new technology, where real-time spatio-temporal ozone information flows all the time and is imperative to be overlaid on a map. Furthermore, the essence of this information is binary (healthy versus unhealthy) and features fast moving spatial borders. Hence, real-time ozone information resembles radar information, where dangerous (storm) versus non dangerous (fair) weather patterns have fast moving borders. Proponents of the second option concluded that for this reason a radar style visualization is appropriate here. They further purported that the first option is a flag style visualization, which may be appropriate as an accompaniment of a textual description but, inappropriate as a dynamic map overlay.

Prior to releasing the application in the App Store, we conducted an anonymous survey of potential users to investigate their perceptions and opinions on the matter. The survey description featured links to two video clips - one with the flag-style interfacing scheme and one with the radar-style interfacing scheme for a specific day and time with ozone activity in the Houston area. The participants were asked to view these two videos and then answer a set of questions. The survey was conducted online through an email solicitation to the University of Houston community (faculty, staff, and students).

The results of this survey, which failed to resolve the issue, are presented in the next section. The impasse resulted in a compromise, where both visualization options are offered under the Settings menu in OzoneMap, leaving the choice to the users (Figure 1). So far, this app has been rewarded with 5 star ratings in the App Store.

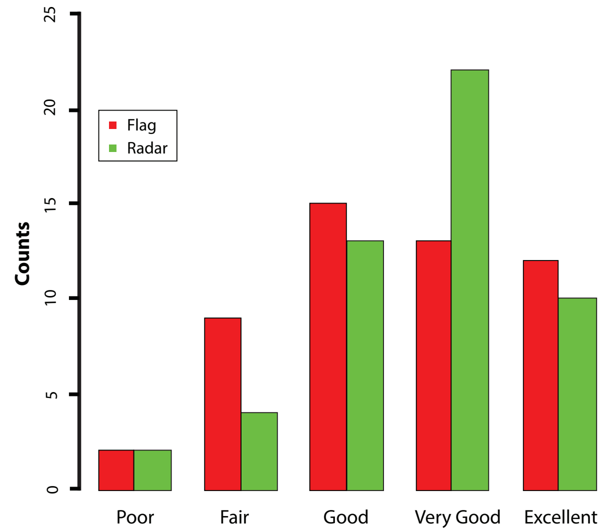


Figure 2: Counts of rating flag versus radar style interfaces for real-time ozone mapping.

3. SURVEY OF POTENTIAL USERS

There were $n = 51$ responders. The results of the first two questions (Table 1), which represent the marginal variables in this study, are shown in Figure 2. The non-parametric Wilcoxon test indicated no significant differences between the medians of the two distributions ($p = 0.2311 > 0.05$). This means that the potential user base appears as split as the design team. The profile of the respondents, as determined by the remaining 6 questions (Table 1), revealed a cohort of mostly young adults in their 20s and 30s ($\sim 82\%$), slightly biased toward the male gender (60% vs. 40%), highly educated ($\sim 66\%$ with M.S. and Ph.D. degrees), who are at least moderately active outdoors ($\sim 85\%$), and check regularly weather reports ($\sim 75\%$).

4. DISCUSSION

History is replete with examples where old interfacing schemes are hard to die, when new technology emerges and rational justification for their use ceases to exist. A famous historical case is the continued adoption of left-side driving by Britons - a leftover from the horse riding days, where left-side riding accommodated sword handling in moments of danger. The fact that the rest of the world adopted a new and more appropriate interface, exemplifies a characteristic cultural split on such matters.

In our case, this split is not only manifested across disciplinary boundaries (environmental scientists versus computer scientists), but surprisingly across a sample of the user base. The deeper reason for this split is not entirely clear and calls for further investigation. It cannot be exclusively debated on perceived usability grounds, as the flag scheme clearly reduces map legibility. It is possible that for some people entrenched notions about communicating hazard information override practical (i.e., usability) concerns. Hence, the specific problem is also related to the theoretical framework concerning the role of preconceptions and individual differences in understanding and using visual metaphors [6][7]. It is certainly a difficult puzzle, far removed from a 'black and white' case, which carries impli-

Table 1: Subset of survey questions related to the marginal variables.

Variable	Description
Flag	Q1: Rate the flag style representation of the evolving ozone data. 1=Poor ; 2=Fair ; 3=Good ; 4=Very Good ; 5=Excellent
Radar	Q2: Rate the radar style representation of the evolving ozone data. 1=Poor ; 2=Fair ; 3=Good ; 4=Very Good ; 5=Excellent
weather_pred	Q3: Do you consult weather predictions over your smartphone and/or the Internet? 1=Never ; 2=Rarely ; 3=Sometimes ; 4=Often ; 5=Very Often
pollutant_pred	Q4: Do you consult pollutant predictions over your smartphone and/or the Internet? 1=Never ; 2=Rarely ; 3=Sometimes ; 4=Often ; 5=Very Often
walk_run	Q5: Do you walk or run outdoors in a metropolitan area? 1=Never ; 2=Rarely ; 3=Sometimes ; 4=Often ; 5=Very Often
Gender	Q6: Gender 1=Male ; 2=Female
Age	Q7: Age 1= Age< 20 ; 2=20 <Age< 30 ; 3=30 <Age< 40 ; 4=40 <Age< 50 ; 5=Age> 50
Edu_Level	Q8: Education Level 1=Primary School ; 2=High School ; 3=B.S.; 4=M.S. ; 5=Ph.D. ; 6=M.D.

cations for emerging lifestyle applications.

In closing, we would like to comment on three open issues that will inform our future work in this area. First, the radar style color scheme does not only use clear coat for the lowest class, but also uses higher transparency for all the other colors. In contradistinction, the flag style scheme uses solid colors that further reduce visibility. The transparency effect has not been studied in isolation and is an issue that calls for further research. Second, because the flag style scheme spans a range form red to green people with color vision impairment may have an added difficulty reading it [4][5] - an issue that also calls for further investigation. Third, we have studied only the perception of potential users about the two visualization schemes; we have not directly measured usability - something that is at the top of our future agenda. It is likely that people who perceive favorably a visualization scheme, may change their opinion once they start using it to perform app related tasks.

5. ACKNOWLEDGMENTS

This work was funded by a grant from the Houston Endowment - a philanthropic foundation dedicated to improve the life for the people of greater Houston. Any opinions, findings, and conclusions or recommendations in this material are those of the authors and do not necessarily reflect the views of the funding agencies.

6. REFERENCES

[1] J. Abraham and A. Comrie. Real-time ozone mapping using a regression- interpolation hybrid approach, applied to Tucson, Arizona. *Environmental Pollution*, 125:369–383, 2003.

[2] R. Delvin, J. Raub, and L. Folinsbee. Health effects of ozone. *Science & Medicine*, 4(3):8–17, 1997.

[3] J. Diem. A critical examination of ozone mapping from a spatial-scale perspective. *Journal of the Air & Waste Management Association*, 54(8):914–925, 2004.

[4] B. Jenny and N. V. Kelso. Color design for the color vision impaired. *Cartographic Perspectives*, 58:61–67, 2007.

[5] B. Wenninger. The effects of colour on the interpretation of traffic noise in strategic noise maps. In *26th International Cartographic Conference - ICC 2013*, Dresden, Germany, August 25-30 2013.

[6] C. Ziemkiewicz and R. Kosara. The shaping of information by visual metaphors. *IEEE Transactions on Visualization and Computer Graphics*, 14(6):1269–1276, 2008.

[7] C. Ziemkiewicz and R. Kosara. *Eurographics/IEEE-VGTC Symposium on Visualization 2009*, volume 28, chapter Preconceptions and individual differences in understanding visual metaphors, pages 1–8. The Eurographics Association and Blackwell Publishing, 2009.