Displaying NHP Health Data in Mobile Devices

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Abstract
Health information is becoming complex as more data types are added and used during health care decision making. Non-human primates have been used as a model to understand human physiology. The authors argue that data collected in the care and management of these animals can be used to inform the development of visualization of complex health information. The authors maintain a web application which is used to upload and access health information for almost 2,000 animals. They demonstrate limitations of the visualizations used in the system and ways they have made design decisions to make the application mobile friendly. The authors propose to use the NHP health data as a platform to develop, evaluate, and test different visualizations of health information.

Author Keywords
Health data visualization; non-human primates; mobile devices.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User interfaces.

Introduction
Health data is complex, and current health records systems are storing more information about subjects

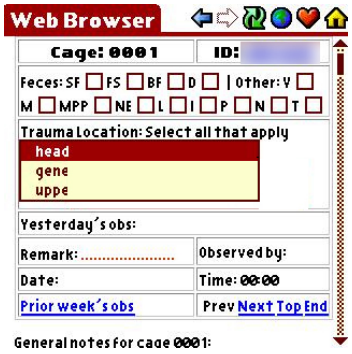

Figure 1: Early web application rendered in a Palm Tungsten C.

with little guidance on how to display and make this data available for making healthcare decisions [6]. In addition, there are no formal evaluations of the data visualization tools used within electronic medical records (EMRs) [1]. Non-human primates (NHPs) have similar health data to their human counterparts. At the Wisconsin National Primate Research Center (WNPRC), we house close to 2,000 animals. Several veterinarians oversee the daily care of these animals and regularly have to make decisions about their health and treatment options. For example, they monitor pregnancies, look up previous weights, or record glucose levels of ageing NHPs. To keep our staff safe from potential exposure to different viruses, all animals are housed behind a barrier that can only be accessed by authorized employees. Staff use personal protective equipment when entering these facilities, including wearing double medical gloves. Users access the animal health record system using center-provided mobile devices and desktops available throughout the animal area.

The center has invested in multiple mobile devices to enter and display animal health data. Currently, multiple generations of iPads are used for entering data and retrieving information. The center has not developed a mobile interface for entering animal data. Some small customizations such as limiting the size of some of the data input forms and the number of rows that can be display within animal lists have been made, however. Nevertheless, our staff uploads data using web browsers, mainly using the desktop version of the web application even on a 9.7-inch screen. One of the goals of the center is to enter data in real time. In order to do this, a better mobile interface needs to be developed—one that can be used for retrieving, analyzing, and entering data at the point of care.

Using NHP health data provides a unique opportunity to explore the presentation of health data to veterinarians, clinicians, and other staff that help in the management of the colony. The insights of this process can inform development of EMRs for humans, expanding translational research to the field of health data visualization.

Evolution of Mobile Devices

The WNPRC has been an early adopter of a variety of technologies to manage, enter, and display health information of NHPs. Staff at WNPRC developed a home-grown database system to store animal data such as health, pedigree, and housing information, irregular observations, and project assignments for NHPs. To reduce transcribing data from paper forms and encourage direct entry, animal care staff initially used Palm devices in the early 2000s. Those were later replaced by Nokia N810 Internet tablet computers. Both devices used a simple web-based interface (Figure 1) that allowed staff to enter information directly into the animal record. The most commonly entered data were irregular observations and cage observations. This allowed for veterinarians to follow up on any problem with animals on a near real-time basis. These early devices had several limitations and they were mainly used for data entry. For example, their screens were too small (i.e. 4.31-inch) which prevented veterinarians and other staff from searching for or analyzing animal health information at the point of care.

In 2009, WNPRC secured funding to develop a modern NHP health record system. Since users were used to

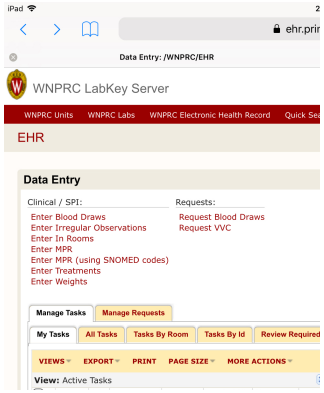

Figure 2: Links to enter data for animal care staff. Depending on the user's role the system displays links to the data they can enter.

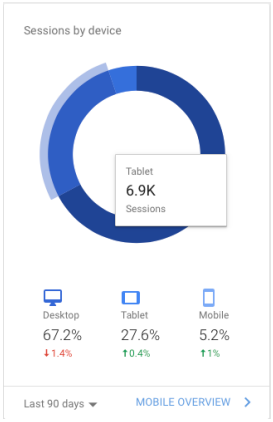

Figure 3: Percentage and number of mobile sessions in the last 90 days.

uploading data directly into the previous system, one design requirement was that the new system would be able to be used behind the barrier and allow for direct data entry. WNPRC staff decided to use a modern web based application called LabKey Server [4] which users can access using web browsers on iPads or desktops. Due to limitations on development time and funding, the data input forms were primarily designed to be used on desktops. Since iPads render web pages to fit within their smaller screens, these devices are used for direct data entry (Figure 2). Currently, staff at WNPRC use iPads and other mobile devices more than 30% of time (Figure 3). Staff use iPads to determine their day-to-day tasks such as adding irregular observations, collecting blood, or completing treatments.

Data Input and Visualization

For the work done at WNPRC, data input and visualization are two sides of the same problem. Staff need to see information about animals to either follow up, perform procedures or treatments, or add data into the animal record. For example, the system currently displays previous irregular observations for any animal so that staff can see this information and determine if the animal needs further attention. Moreover, these irregular observations are then evaluated by the veterinarian in charge of the area. This allows vet techs and veterinarians to focus only on animals that need their attention. Figure 4 shows the data entry form for all the animals in a room. There are some rooms with a large number of animals, so in those cases staff needed to scroll to select the animal in the grid and then add the corresponding observation on the right side of the panel. One small fix to this form was to limit the size of the grid to fit within the iPad display. The grid portion allows the user to scroll to see all animals in a room, while the form section to the left only has a point and tap interface consisting of radio buttons and check boxes. The "Remarks" and "Other Behavior" sections allow for free text entry, where staff can use the keyboard to add any text. "Remarks" also has predetermined text selected from a drop-down menu.

The majority of visualizations used in this system were developed to be displayed on a desktop. Although staff can access the majority of information for any animal on mobile devices, some of the graphs are not ideal for a smaller display. For example, Figure 5 shows a pedigree plot for an animal rendered on an iPad. Due to the limitations of the smaller display it only shows half of the pedigree tree. Figure 6 shows the complete pedigree on a desktop. This limitation of the display is due to the webpart used to display the graph as well as the R library used to create the graph. Both of these limit the width making it difficult to resize the graph on the iPad's web browser.

A similar problem was encountered with the display of weights for an animal (Figure 7). All animals get weighed at least once a month and in some cases every week. These data are used to assess the overall health of an animal and development of newborns. Due to limitations with the graphing tool used to generate this chart, users were not able to zoom in to see details about the weight of a given animal. A simple solution was to add a second tab to display the same graph but limit that graph to only show data from the last year. This helps to determine if the animal is recuperating from any recent health problems. Both graphs are rendered at the same time, so the user does not have

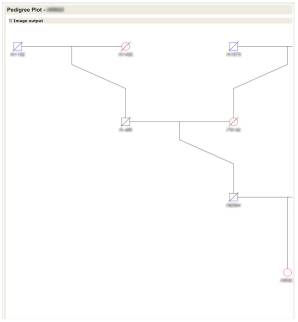

Figure 5: Pedigree plot rendered in an iPad, only shows half of the tree regardless of the orientation.

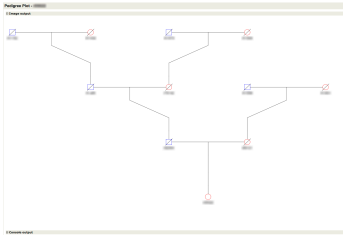

Figure 6: Complete pedigree plot displayed in a desktop computer.

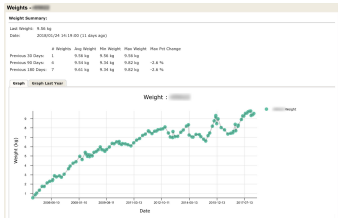

Figure 7: Weight graph for a 12-year old animal.

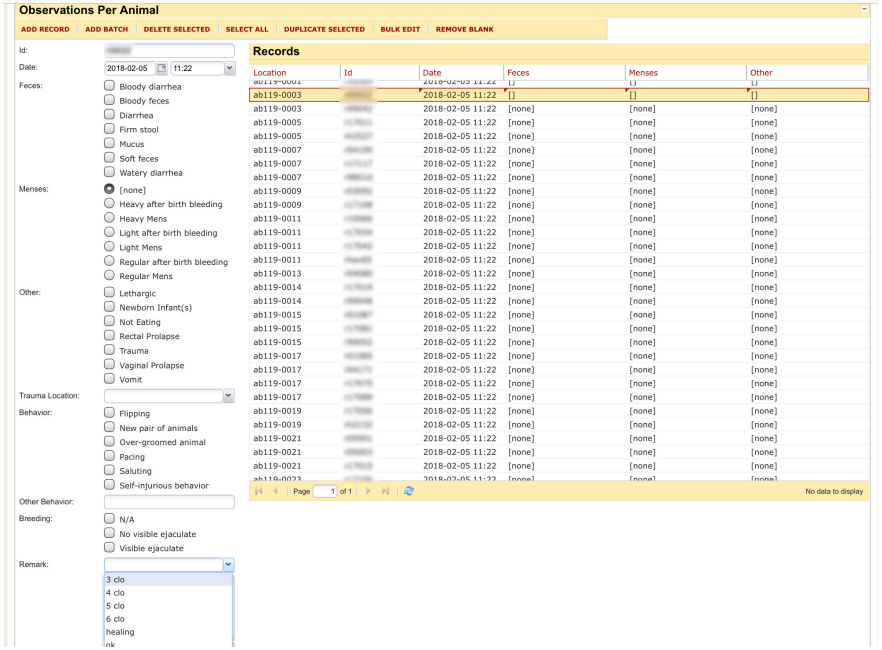

Figure 4: Entering observations for a whole room. Left column shows all the type of observations that can be entered. The right grid shows the list of animals in the room. Room ab119 has more than 60 animals.

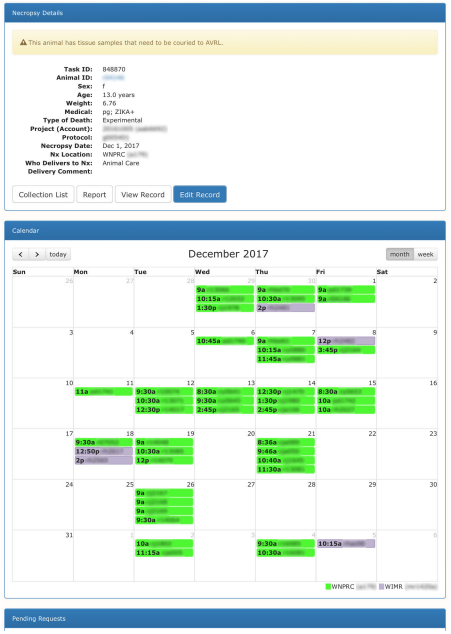

Figure 8: Necropsy calendar displayed in an iPad. In a desktop the panels display side by side.

to wait for another AJAX call when flipping between tabs. Having different tabs is a viable alternative when mouse scrolling is not available on mobile devices, which is the case with some JavaScript visualization tools (such as D3) [7].

For some of the latest development, we are using modern user interfaces like Bootstrap [9] and ReactJS [8], which allow for the page to be rendered according to the device constraints. For example, Figure 8 rearranges the panels based on the width of the device.

Expanding Data Visualization of Health Data

Veterinarians, researchers, and staff at WNPRC and other primate centers are constantly adding new data types to the animal record. Their requirements are similar to those of clinicians in hospitals and other human health care settings [5]. Currently, our system can store full genome sequence data as a raw file attached to the animal record. The user needs to download the file and use another application on their

computer to analyze this information. This approach can work for expert users who might already have the software required to analyze this data. For the naïve user that might only want to explore the animal record though, an embedded interface within the health record system that can display this information may be more useful. Additionally, having this data available on a mobile device can help clinicians make health care decisions at the point of care. Using human health information to test different visualization options might be too challenging because of local, state, and federal regulation such as HIPAA and others that govern human EMRs [2].

NHP health data does not have regulations that are as stringent on the use and storage of data. Their data can be aggregated, summarized, and displayed to help veterinarians make decisions about their care and housing arrangements, and to inform future research projects. Studies on using animal health data to manage the health of NHPs have the potential to guide the implementation of such visualizations in human EMRs. An alternative could be to use de-identified data from human medical records or even simulated health data [3], but these approaches lack realism of the environment [1]. They also limit the ability to conduct tests, do formal evaluations of the visualizations developed within the system, and receive feedback from users making health decisions for real subjects. Furthermore, the fidelity of the environment where the system will be used is similar to a human health care setting.

During the workshop, the authors plans to demonstrate the current system and some of the early data visualization tools we currently use. The goal of participating in the workshop is to guide the development of newer data visualization based on best practices and experience from researchers that have worked in this area.

Conclusions

NHP data provides an excellent opportunity to test different options for health data visualization in a realistic environment. The WNPRC has a long experience using mobile devices to manage and gather data from NHPs. Some of these animals live long lives and the center maintains health and pedigree information for more than five generations of animals. This data can be used to explore data visualization by building cohorts of animal families or aggregating data from new data types such as full sequence genome data.

The outcome of this exploration has the potential to benefit not only other primate centers that use a similar system to the one used by WNPRC, but also the larger human computer interaction, health informatics, and health data visualization communities.

Acknowledgements

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