Research Brief

Battery Extension Tool

A study of smartphone battery demand and conservation modes

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Introduction

Power utility affects communications resiliency. When cellular networks have been restored to areas experiencing power outages, many are still unable to use their wireless devices due to an inability to charge the batteries. This may be particularly disturbing for people with disabilities who rely on their wireless devices' accessible and assistive technology features to send and receive critical information.

The project surveyed power controls that currently exist within current mobile operating systems and evaluated the battery demand of wireless devices, comparing typical operation with optimal battery operation while various accessibility apps are in use. These data were analyzed to develop recommendations for best practices for battery charge extension of wireless devices. A proof-of-concept, customizable user interface prototype app, the Battery Extension Tool (BET), was developed to allow users with disabilities to implement these best practices while retaining access to their accessibility software.

Methods

Prototype App Development

BET was developed as a proof-of-concept Android application. BET collects all settings that affect battery charge into a single interface. The tool displays the current state of each setting and recommends configuration values based on the selected disability. The user may select one of four disability categories to receive targeted suggestions for configuration values. Categories include low vision, blind, hard of hearing (HoH), and deaf (Figures 1 – 5). Selecting the category customizes the recommended configuration values for each setting, with matching values shown in green and non-matching configuration values in red. When the user selects the control, the system page for that setting is brought to the forefront for the user to make the change. The updated value is displayed when the user returns to the settings program.

Figure 1: Home screen

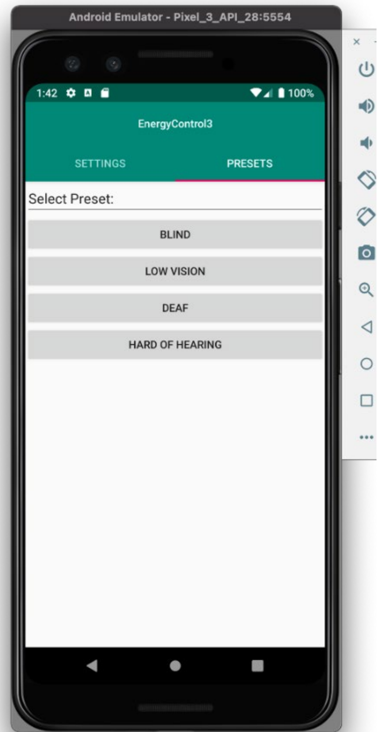


Figure 2: Low Vision Settings Screen

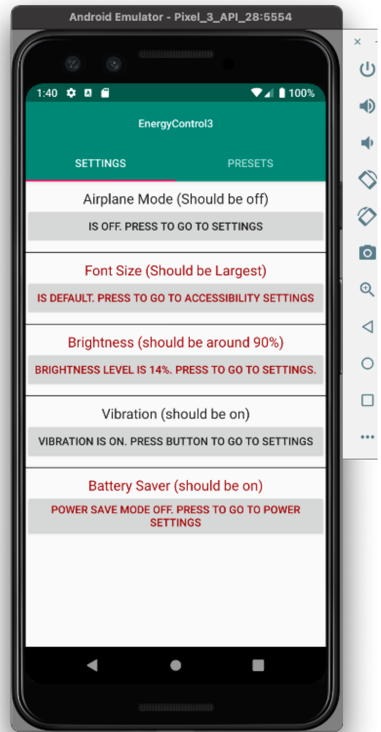


Figure 3: HoH Settings Screen

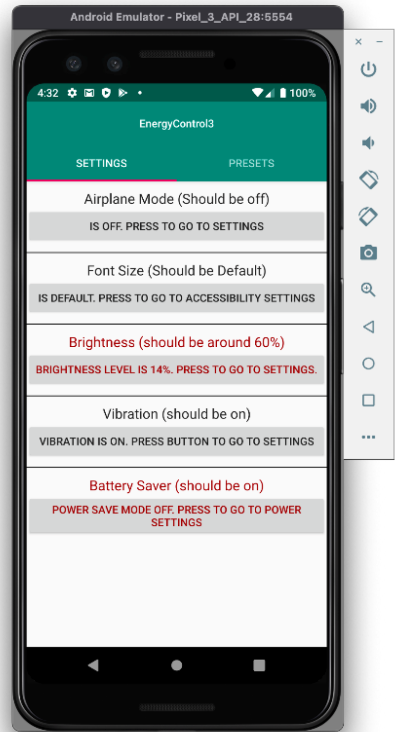


Figure 4: Blind Settings Screen

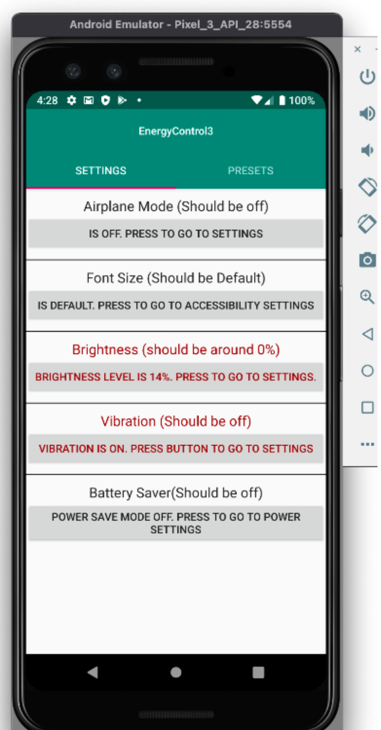
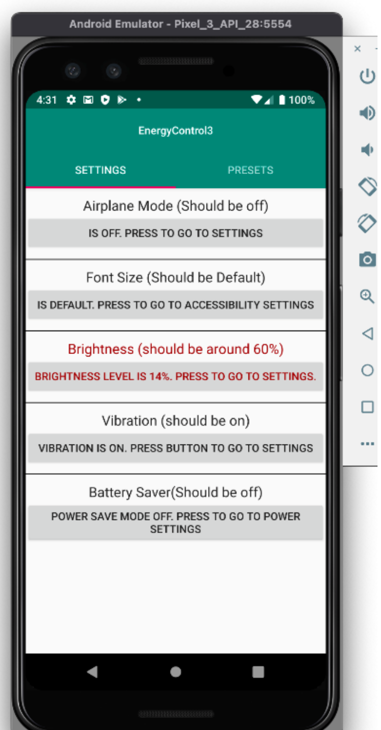


Figure 5: Deaf Settings Screen



Focus Groups

To evaluate BET, focus groups composed of individuals with hearing and vision disabilities were convened to explore their experiences with and perceptions about smartphone battery drain and preservation during extended power outages. The main objective of these focus groups was to collect input on BET. This prototype app allows users with disabilities to implement best practices for battery conservation while retaining access to accessibility software. Focus group questions queried the actions people typically take to preserve battery. Subsequently, BET was demonstrated. Focus group questions then queried impressions of the app, its usefulness in changing the settings, and whether functions or settings are missing from the prototype.

Results

General and Assistive Technology Usage

Participants reported using assistive software and accessibility features for display (high contrast), input /output (speech to text and text-to-speech), output (voiceover, TalkBack, Braille Reader, captioning), and perception (haptics, vibration, BLE connected Cochlear Implants Hearing Aids). Two-way video, while not designed to be an accessibility feature, was heavily used by participants who are Deaf to communicate via sign language with family and friends. The brightness level was also indicated as an access need for persons who are Deaf and Hard of Hearing as they rely on their sight to interact with the screen, while participants who are blind and many who are low vision defaulted to using voice input and output. Additionally, the participants reported using many accessibility apps like captionmate, BeMyEyes, Aira, and Voice Scanner Reader, among others. Like their non-disabled cohorts, the participants also used apps for productivity, news, banking, communication, transportation, shopping, and entertainment; and connected their phones to external technologies like wearables and smart speakers.

Typical Usage Demand and Battery Conservation

Time spent using native and downloaded apps and accessibility features underscores the importance of maintaining a charged battery. On a typical day, participants reported a range of 2-12 hours spent using their smartphones, with the majority reporting between 5-8 hours of daily usage. Many participants shared their vigilance about preserving battery, especially when in the community. Participants that used paratransit expressed extreme concern about battery preservation because they lack control over how much time will be spent in transit. Other measures taken included plugging the phone in whenever possible. One participant explained, "I have been really frustrated with how you have to charge the battery. People in the Deaf community talk on the phone for 30 minutes as a video chat, and they are tied to their charger.

How do I handle being out, and I always need a charger with me and need to find a plug?" In agreement, another participant stated, "I always am charging my phone. All the time. I feel like I am tethered to my charger."

Extended Power Outage Usage Demand and Battery Conservation

Almost all participants had experienced an extended power outage. The common theme across disability types was the critical need to maintain communications. So, precautions are taken to conserve battery charge when an outage is anticipated. However, it is important to note that some outages are unexpected. For example, one participant who is blind shared that she lost power due to a vehicle colliding with the utility poll that powers her neighborhood. Her phone was already at 40% in that case, "and it didn't last the whole power outage." Other participants shared their experiences with three-to-five-day long power outages. For many, their phone's battery also drained before power was restored. As a result of these experiences, safeguards are taken, such as pre-charging their phone at the threat of an outage (e.g., thunderstorm). Other precautions included not using the phone, turning off data, closing all apps, stopping background refresh on apps, turning to other devices such as a tablet for entertainment, and putting the phone in low power mode. However, the latter was not perceived as an option by some of the participants who are Deaf, as they reported that low power mode disabled video functionality. In addition to battery conservation behaviors, participants shared that they relied on alternative sources for charging, such as vehicles (for those who owned one), businesses with power (if safe to travel), backup batteries, and external battery packs/portable chargers.

Post Battery Extension Tool Demonstration Feedback

After the demonstration, participants were asked to rate the app on a scale of 1 to 5, with one being not at all useful and five being extremely useful. The prototype received an average rating of 4.3. The blind and low vision groups had the highest ratings for the prototype. About half of them agreed that the reason for not giving a five-star rating was because they would want to test how well it works in real life. The hard of hearing and Deaf groups gave the lowest ratings. Those that rated it highest across all groups commented on its ease of use related to navigation, the quality of the voice output, its simplicity, and it auto redirects the user to the corresponding setting in the OS.

Specific to participants who are blind, they noted that some features are unknowingly enabled or changed (e.g., flashlight, volume, brightness). "If you swipe down from the top, it opens control, and you can accidentally turn on features you don't want or need," noted a participant who is blind. "My problem is my ringers. If I turn down a voice on the phone, I don't hear my ringer…should be able to adjust voice volume and not ringer volume. Would like to be alerted when the ringer volume is low," shared another. So, an audible informational indicator (not just a sound, e.g., audible output saying "flashlight on") would help mitigate battery drain due to accidental feature activations/changes.

During ideation, the prototype app use case was in the wake of an emergency/disaster event that interrupted utility power service. However, the researchers did not anticipate the hypervigilance of people with hearing and vision disabilities concerning smartphone battery preservation during typical periods of use. So, although the long-term outages inspired the need for this app during hurricane and fire seasons, focus group participants indicated that it would be useful in the regular day-to-day context. Other recommendations included:

- Auto close all apps
- Include other battery-hogging features
- Add a pop-up that informs the user of everything open on the phone
- Dynamic battery conservation mode that automatically ratchets down certain functions when the phone is in use.
- Add a meter that displays how changing the settings impacts battery charge extension or reduction

Discussion

There are certain phone features that are a requisite for effective use regardless of circumstances, whether it be a typical day or in the wake of a disaster. With our participants, concomitant with the use of two-way video was the need for high brightness levels, which places the phone in double-jeopardy of rapid battery drain that is tied to communications access. Persons who are Deaf are seemingly differentially impacted by battery drain issues as their use of video and high brightness levels are required to maintain communications on a normal day and during emergency events. Whereas the participants who are hard of hearing, blind, and have low vision, reported not using their access features if there was the threat of a power outage.

Participants suggested expanding the app to other phone features besides what we have identified (Figures 1-5), such as turning off GPS and mobile data. Both are worthy inclusions in a future iteration as the testing to identify the current settings was in a fixed location, lab environment, so GPS/location services were not tested. However, since GPS-powered map apps default to keeping the screen on, it is worth testing the battery drain of maps/wayfinding apps to determine the different configurations for this use case based on disability type. For example, since a person who is blind does not need to see the screen, running a map app without the screen on would be the ideal setting to conserve battery. Similarly, regarding mobile data, testing its effect on the battery would require testing mobile data turned off in conjunction with the use of other features and apps to understand to what degree the experience may be degraded by relying on Wi-Fi only. For example, mobile data usage and social media apps go hand in hand.

What are the consequences of turning off mobile data in the wake of an emergency if people are using social media to let others know they are safe or, conversely, need help? Regarding location-based services, in what situations would such services need to be fully functional?

Conclusion

Including device manufacturers in discussions about optimizing smartphone batteries, particularly leading up to and post-disaster, is critical. There are currently recommendations that center on limiting the phone's functionality to conserve battery, such as turning off location and GPS services. However, these same services could allow people to be found during post-disaster search and rescue. Furthermore, as was illustrated, certain features are considered indispensable during times of emergency. Including device manufacturers as a key communications resiliency stakeholder could prove an asset to mitigating the negative effects of post-disaster power outages, namely communication disruption due to battery drain, on persons who are deaf, hard of hearing, blind, and low vision.

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