Figure 1: Stelter ending his section hike of the AT with technology

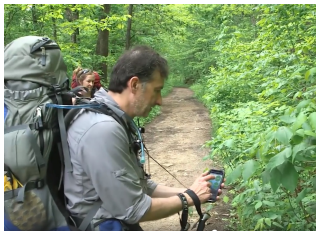

Figure 2: Jelesko using a mobile app to collect data on poison ivy

Figure 3: Close up of Jelesko's phone.

Understanding the Context for the Pursuit of Science on the Trail

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Abstract
Understanding the rising tensions between technology and the outdoors is becoming more of an issue as technology becomes more mobile and wearable, requires lower power, and becomes more durable. With increases in technology use outdoors, there will be increased amounts of data from the trail (both device and user triggered). This paper seeks to develop an understanding of the common data needs of researchers for science on the trail, focusing on geolocative, temporal, and data collection opportunities in three situations, examining opportunities for computer science and human computer interaction (HCI) to help to understand the context, influence the design space, and balance roles for technology in the outdoors.

Author Keywords
Mobile, citizen science, nature, outdoors, design

Introduction and Related Work
In HCI we strive to understand the design of interactions, experiences, and the relationship between people and technology. However, HCI research in the outdoors environment has only recently been brought to the forefront. A recently formed framework introduced by Yvonne Rogers in Figure 4 can be used to help conduct "in the wild" HCI research by focusing on the four principles: design, technology, in situ, and theory [17]. These four principles are starting points

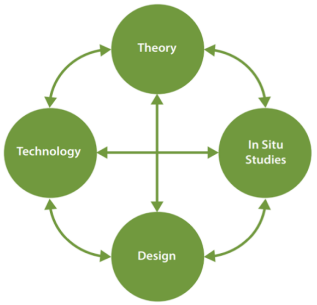

Figure 4: Rogers' RITW framework used to identify 4 key elements with for an "in the wild" study.

Figure 5: Marion on the AT.

when confronted with unstructured research problems in the wild (frequently due to conducting the research in an uncontrolled environment outside of the lab such as on the trail). Before the introduction of this framework there were not many "in the wild" research guidelines for researchers to use in understanding technology's appropriation by communities or individual users in the wild. Our focus user groups such as hikers, rock climbers, distance walkers, and other outdoor enthusiasts value their time in the wild away from technology, yet they increasingly bring mobile devices such as smartphones, GoPros, smartwatches, biometric sensors, GPS devices, and more on their adventures. By taking technology out on the trail, the context of how a device is used changes and may be leveraged by researchers.

Context of technology

Ellie Harmon examines how smartphones became a widely-used device out on the Pacific Crest Trail, one of the triple crown trails spanning 2,650 miles in the United States, where users commonly used it for maps, music, camera, communication, a light source, a diary tool, and more [6]. During her journey, Harmon collected many stories relating to smartphone culture and has inferred how we as individuals experience it, design for it, and frame our research questions in building upon this culture while adhering to the smartphone culture and values[5]. Recent work Anderson et al. explored various contexts such as reflection and motivation, safety, social aspects, sensing, notifications, and other specific contexts on how smartphones play a part in our outdoor experiences [2]. Because of this observed phenomenon we see an interesting design space for many different technologies out on trails. An example on this space is the HOBBIT asocial smartphone app by Posti et al. that supported user enjoyment of a solitary experience by helping them in avoiding other people on the trail [16].

Technology on the trail

The Technology on the Trail initiative presents three themes outdoor enthusiasts: preparation, experience, and reflection [1]. This begs the question, why do we bring technology on the trail? What core concerns can form the basis for designs, code bases, and evaluation plans? Based on prior literature from the previous section, and our own experiences, we present the following lenses for designing trail technology with science, engineering, and recreation in mind.

- Geolocation. Associating place with artifacts and events is important when on the trail. Maps are a key tool, particularly when you cannot count on signs to bring you to your next meal in a matter of minutes. Regions and areas need to be delineated to indicate geographical features.
- Temporal identification. People tend not to move quickly on the trail, and the impacts of nature are quite literally in your face. Associating temporal information with artifacts and events can provide context and reflect change.
- Data collection. Certainly this is a particular concern for science and engineering, but it is also relevant for users trying to preserve their experience in a physical or digital artifact. Example data can be videos, pictures, audio recordings, writings, temperature, and biometric data. Processing and reflecting on this data can help model new observed phenomenons and/or relive experiences with additional context.

Trail experiences

There exist many activities on the trail. Each activity holds a way of thinking and internalizing experiences from the outdoors that then can be used to advance science. Examples

of these activities hiking, walking, scouting, backpacking, story-telling, hunting, mountaineering, climbing, activism, conservation, camping, and so much more. Each activity produces experiences and reflections that can be exemplified through physical/digital artifacts such as writings or blogs the both the user and general community can use. These artifacts can be used to help inform many areas in the science domain. We present two Virgina Tech professors whose research brought them to utilizing technology out on the trail that can benefit their work.

Science and the "Poison Ivy League"
John Jelesko (seen in figure 2) dedicates his lab to poison ivy, a common invasive plant found in eastern North America. Jelesko and his colleagues currently manages a citizen science, a form of crowdsourcing where volunteers help generate and process data, website where anyone can submit data (locations, timestamp, and pictures of the surrounding area) on poison ivy to support his efforts in collecting data on poison ivy along the AT [8]. Jelesko has shifted his focus on the broader communities and tapping into newer citizen science ideas using smartphones to help collect this data.

We have initiated a semester-long project focusing on creating a mobile app to be used by a general audience to collect poison ivy data. The data collected will allow him to create a model to predict poison ivy spread, understand their growth patterns, and understand their dormancy state. The design space for this app is very broad and an interesting challenge lies in how will those on the trail take to helping out in this cause.

Nature and sustainable campsites
Jeff Marion focuses his work in recreational ecology where he studies the impacts from visitors to various US national parks and campsites. His current work is on finding management solutions for dispersing campsites to geographically located areas that naturally provide barriers to prevent the growth of a singular campsite to many visitors that can span 100s of feet. Marion believes that the smartphone is replacing older conventions with respect to navigation and trail information and thinks it will be one of the biggest changes to the "leave no trace" mentality as a whole new set of benefits and concerns arise with a society using more digital technologies outdoors [11, 12]. After exhausting typical management solutions like signs, educational booklets/videos, fencing off areas, Marion believes technology will be provide the solution.

To this effort, we joined with Marion in crafting an app to help identify sustainable campsites and collect location, temporal, and pictorial data to reduce the ecological strain on overpopulated campsites. The primary focus of this application is to easily relay information to visitors of national parks with the secondary focus being on collecting visitor generated data and produce models to showcase the positive impact on these areas overtime.

Recreation and Hikes with Technology
Tim Stelter hiked a section of the Appalachian Trail (AT) with a predetermined set of technology based informal discussions with self-identified hikers, weight, cost, power needs, quality, durability, data collection and exporting [18]. The hike exemplified the three core concepts of technology on the trail (TotT) preparation, experience, and reflection [1]. Each phase has a critical piece to understanding how a hiker begins and ends their hike (including the first author's hike). Like many hikers, through experiencing the hike Stelter felt rejuvenated, as the impacts of experience nature has proven beneficial and rejuvenating to the human psyche [4].

Figure 6: First author setting up devices implicit interaction photo capturing on the Huckleberry Trail in Blacksburg, VA United States.

Figure 7: Simple watch interface for our heart rate implicit interaction app.

Future directions

We presented three areas of science in plant pathology and physiology, recreational ecology, and outdoor tech-enhanced hiking. Each domain has unique problems to solve, and each has opportunities for utilizing technology for the outdoors. The common need for data relating for location and time in these domains is well established (although for very different reasons). While location and time are highly desired by Jelesko and Marion, other data such as photos helps increase the context and allows for greater understanding of the given data point. With many communities set in outdoor activities on the trail millions of these data points are being generated everyday. There lies overarching opportunities for computer science and HCI in processing, understanding, visualizing, storing, reflecting, experiencing, modeling for data and leveraging these communities to gather the data.

Digital and mobile opportunities

An under explored opportunity exists to leverage mobile devices to help researchers collect needed data for domains such as habitats of ticks and pine beetles, spread of invasive plants like poison ivy and garlic mustard, recovery of wildfire-ravaged areas, and damage to bridges, roads, trails, shelters, campsites and other structures near the trail. Citizen science has great promise when paired with mobile technology [7, 9, 10]. Yet there is danger for failure if we overburden people who are seeking to escape from technology with tech-based tasks [13, 14, 15]. We explored this idea in figures 6 and 7 by using implicit interactions through heart rate detection to capture photographs to allow the technology to do the work. However, the quality and sentimental feeling towards the photographs may not be a part of the experience while on the trail. This opportunity begs the following research questions:

1. What technologies do outdoor enthusiasts use on their adventures, and how willing are they to bring novel technologies and applications on the trail?
2. How can multi-device interfaces capture data useful for scientists? How can the interfaces notify users of trail-based information needs, often tied to location or time, while not overburdening them with excessive or intrusive tech interventions at moments of solitude?
3. How can we assess the quality of our mobile interfaces, in particular to determine the value of citizen science? Are the interfaces acceptable to users; indeed, do they engender a sense of contribution to a greater good? Is the input from citizen scientists of sufficient quality to advance the science?
4. How can we store and share data while in outdoor settings? How can we overcome the unreliable connectivity issues that support storage of large amounts of data? How can we share data with others in ways that support a need for privacy while meetings others' need for timely information?
5. How do we design for a citizen science community to facilitate collaboration on the trail without affecting the user experience? What are the best practices we can create to facilitate motivation, community, and a sense of accomplishment?

Balancing the roles of users and technology

An interesting challenge is understanding the roles an outdoor enthusiast will take when engaging with technology outdoors. We know very well how technology is saturated in our cities and urbanized areas which cause a lot of technology not to be our primary focus. But out on the trail we are dealing with a different perception entirely. Because of this shift of the environment our perception of technology is brought to the forefront of our minds and causes potential issues with user experience and design outdoors [3].

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