Snake View: Exploring Thermal Imaging as a Vision Extender in Mountains

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Figure 1: Proof of Concept prototype consisting of Head Mounted Display with augmented RGB, Depth and Thermal Cameras.

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Abstract
Human's vision can only operate in the limited visible band of the electromagnetic spectrum. Using commercially available imaging sensors can be beneficial to extend human's visual perception in different environments. Typically, these environments include challenging conditions, for instance smoky views during a fire or occluded, foggy, cloudy and windy view in mountain environments. Recently, thermal imaging became more commercially available, which makes utilizing it to extend the human's visual perception affordable and deployable. In this paper, we propose the usage of thermal imaging as a vision extension tool. Two initial prototypes are presented depicting the different form factors of thermal cameras attachment to Head Mounted Displays. Finally, we discuss potential use case of extending the human's vision to cover the thermal spectrum during mountains activities.

Author Keywords
Thermal Imaging; Ubiquitous computing; Glasses; Head Mounted Displays.

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

Introduction & Background

The visible band in the electromagnetic spectrum compromise an extremely limited portion of the total electromagnetic spectrum. As shown in figure 2, less than 1% of the total light waves reaches our eyes in the visible spectrum. It's estimated to be .0035% of the entire electromagnetic spectrum. This is limiting our awareness and perceived information of our surroundings [10].

This applies to daily life, and this visual limitation is magnified in special scenarios. Given the special environment and surroundings of the mountains, our vision may fail to capture full sense of our environment, which might induce hazards [4].

Researchers explored the extension of human sensing with either augmenting the environment using sensors and projectors like the work presented in [5]. Others explored augmenting the human by using wearable sensors [7].

In both strands researches utilized depth cameras operating in the near infrared to enhance depth sensing. Depth cameras e.g. the Kinect are attractive to deploy, given their operating nature, they operate unobtrusively and in the non-visible spectrum, hence, not occluding with the user's visible experience.

However, when considering special environments like mountains, we should consider ubiquitous user-augmented sensors. Typically climbers utilizes infrared goggles to explore the environment [6], however, one major limitation is the explicit and obtrusive experience. In other words, the climber has to explicitly reach out for the goggles.

Additionally, climbers normally wear dark glasses for protection [6]. Accordingly, the design and development of a vision augmenting ubiquitous system is facilitated, where

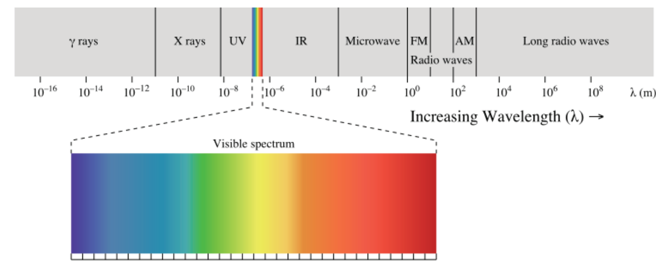

Figure 2: Electromagnetic Spectrum depicting the limited visible portion.

the augmentation will be achieved by attaching the imaging sensors on the typical tools. As shown in figure 1 and 3, different imaging technology could be attached and the feed is displayed to the user via a Head Mounted Display or smart glasses respectively. Figure 1 depicts a proof of concept prototype, yet figure 3 shows the potential form of the prototype using a commercial miniature FLIR lepton thermal camera [1].

In this workshop paper, we are presenting thermal imaging as a novel commercial imaging sensor, as it was considered earlier a special expensive tool. Moreover, it was exclusive to certain user groups e.g. firefighters, medical and security personal. Finally, we are discussing how it could be used to amplify human's visual perception.

Our primary aim of this workshop paper, is to introduce the concept of amplifying the visual perception via thermal imaging to open discussion with expert researchers in the field of ubiquitous computing in the mountains on how to fully utilize such imaging technology.

[1] http://www.flir.com/cores/lepton

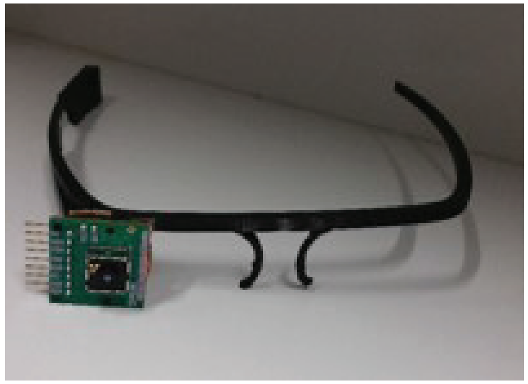

Figure 3: Miniature FLIR lepton thermal camera attached to a 3D printed glass, envisioning the potential form factor.

Thermal Imaging

Thermal imaging operates in the infrared band in the electromagnetic spectrum as shown in figure 2, i.e. it captures waves invisible to our eyes.

The infrared spectrum is divided into four sub-bands: (1) Near Infrared (NIR), (2)Short Wave Infrared ,(3) Mid Infrared (MIR) and (4) Far Infrared (FIR) also known as Long Wave Infrared. All four bands are used to passively capture a heat map of the scene. However, the four bands are used for monitoring different temperature ranges as well as different wavelengths, and hence operates using different imaging sensing technology.

The NIR imaging operates between the 0.7 to 2.5μm wavelengths. NIR is quite expensive, hence, used in the industrial space, given its temperature and price range.

On the other hand, thermal cameras operating in the FIR spectrum with wavelengths between 7.5 and 13μm can capture temperature ranges between -20°C and 900°C. FIR thermal cameras are considered to be the most commercially available thermal cameras in terms of size and cost [2].

Due to the operation nature and price thermal imaging, their usage were limited to certain domains such as medical and firefighting. However, the evolution of commercial, relatively cheap thermal cameras operating in the FIR band introduced a diverse new set of applications. In recent research we explored the potential applications of thermal cameras, highlighting the potential of using thermal cameras in the HCI domain and Ubiquitous computing [3, 9, 1, 2].

Potential Usecases

Based on our previous research, thermal cameras allow sensing thermal properties like heat conductance, transfer and reflection. Based on these properties we envision set of potential use cases in mountains.

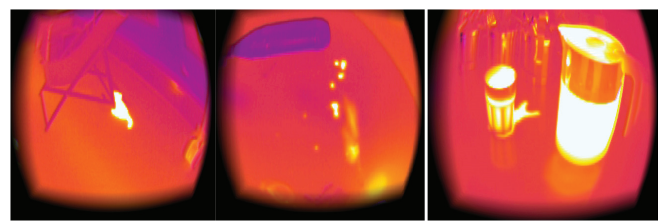

Figure 4: Sample Images from thermal camera showing hidden cat-shaped bottle, leakage of water bottle and level of water inside a kettle.

People Finder

In emergencies and missing persons in the mountains typically the rescue team send out helicopters to search for the missing person. Recently a dog was rescued from being

[2]http://www.flir.com

lost in the mountains using a thermal camera on a drone [3]. In this case, the body heat is utilized to locate the dog. It utilize the thermal blackbody radiation property, where it depends on the object's temperature as expressed by the Planck's and Stefan-Boltzmann laws.

Where bodies above zero temperature emits thermal radiation which is captured by thermal camera making it distinct from the environment. Having climbers wearing the setup with thermal camera attached will drastically facilitate the localization of their fellow climbers or even the existence of wild life. As well as, the basic usecase where they can utilize thermal cameras to visualize the scene in the dark and windy environments, given that thermal cameras operates in a illumination and environment independent manner.

Path Finder

Another thermal property is thermal transfer, where heat is transfered between any two objects in contact. Basically, when a leading climber goes through ice or touches a rock, heat is transfered leaving a heat trace visible using thermal imaging. This trace lasts even after leaving the location, this could be beneficial to keep the group together in case of group climbing. Where they follow the trace instead of the leading climber in case he/She is not in the field of view.

Tools Monitoring

Thermal conductance allows the visualization of the content of containers, for instance, we can visualize the state of the oxygen tank. This allows the avoidance of any unexpected lack of oxygen where climbers always observe the level and state of their tools. Additionally, thermal cameras can visualize gas leakage and air with distinct temperature allowing spotting leakage points or source of hot/cold springs.

[3] http://www.express.co.uk/news/uk/782506/Dog-rescued-mountains-drone-thermal-imaging-wales

Assessment of Decisions

Thermal view could also be beneficial in assessing the decision and avoiding dangerous steps. For instance, thermal cameras depict the temperature of the scene, which helps indicating the thickness of the ice based on the intensity of temperature distribution. As well as shape visualization of sharp rocks.

Conclusion

This workshop paper presents how thermal imaging could sense and depict thermal properties e.g. heat transfer that can not be perceived by our naked eyes. We presented two form factors for potential vision augmentation tool, using a head mounted display as well as miniature glasses highlighting the potential of ubiquitous and unobtrusive deployment of thermal cameras in climbing tools.

Based on the findings from our previous research on using thermal imaging, We presented an overview of possible utilization of thermal properties to enhance and secure the mountain activities experience for climbers.

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