A Vision Based Equipment For Observation of Lemmings Under Snow in the Arctic

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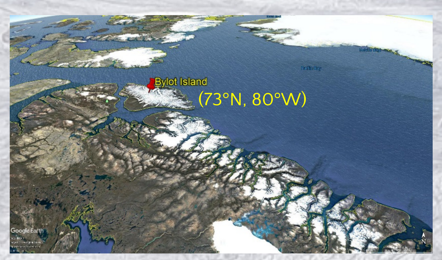

Abstract

Despite the crucial role of lemming in the Arctic ecosystem, many aspects of its ecology are still unknown. The main challenge of studying lemming is that this rodent does not hibernate in winter and remains active under snow. To tackle this challenge, we propose a vision-based equipment in near infrared spectrum. Design and implementation of a system that should work autonomously in the harsh arctic environment is really challenging. After developing the first version of the equipment, we installed three units at Bylot Island, Nunavut, Canada. Retrieved videos were promising and showed the great potential of this system in assisting ecologists to study the subnivean ecology of the Arctic.

Lemming Role in the Arctic Food Chain

Figure 1. Lemmings are of crucial importance to the web of life in arctic regions due to their role in the food chain [1].

Problem Statement

Despite a tremendous amount of research over several decades (e.g., see [2], [3] and [4]), the boom and bust cycles in the lemming population has yet remained an unsolved controversial issue in ecology and no consistent, strong, and widely accepted explanation can be found in the literature [5]. The same thing can be said about many other aspects of the ecology of this small rodent.

As also suggested by some other researches [6], we believe underlying cause of this problem is the lack of direct studies on the winter breeding and life of lemmings under snow.

To the best of our knowledge, no appropriate electronic system has been developed yet to observe lemmings beneath the snow under the Arctic conditions with reliable performance and satisfying required features.

Research Objective

- To develop a vision-based equipment in near infrared spectrum to monitor lemmings under snow.

This equipment is supposed to assist animal ecologists and biologists to study the behavior of lemmings during winter.

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Research Challenges & Implications

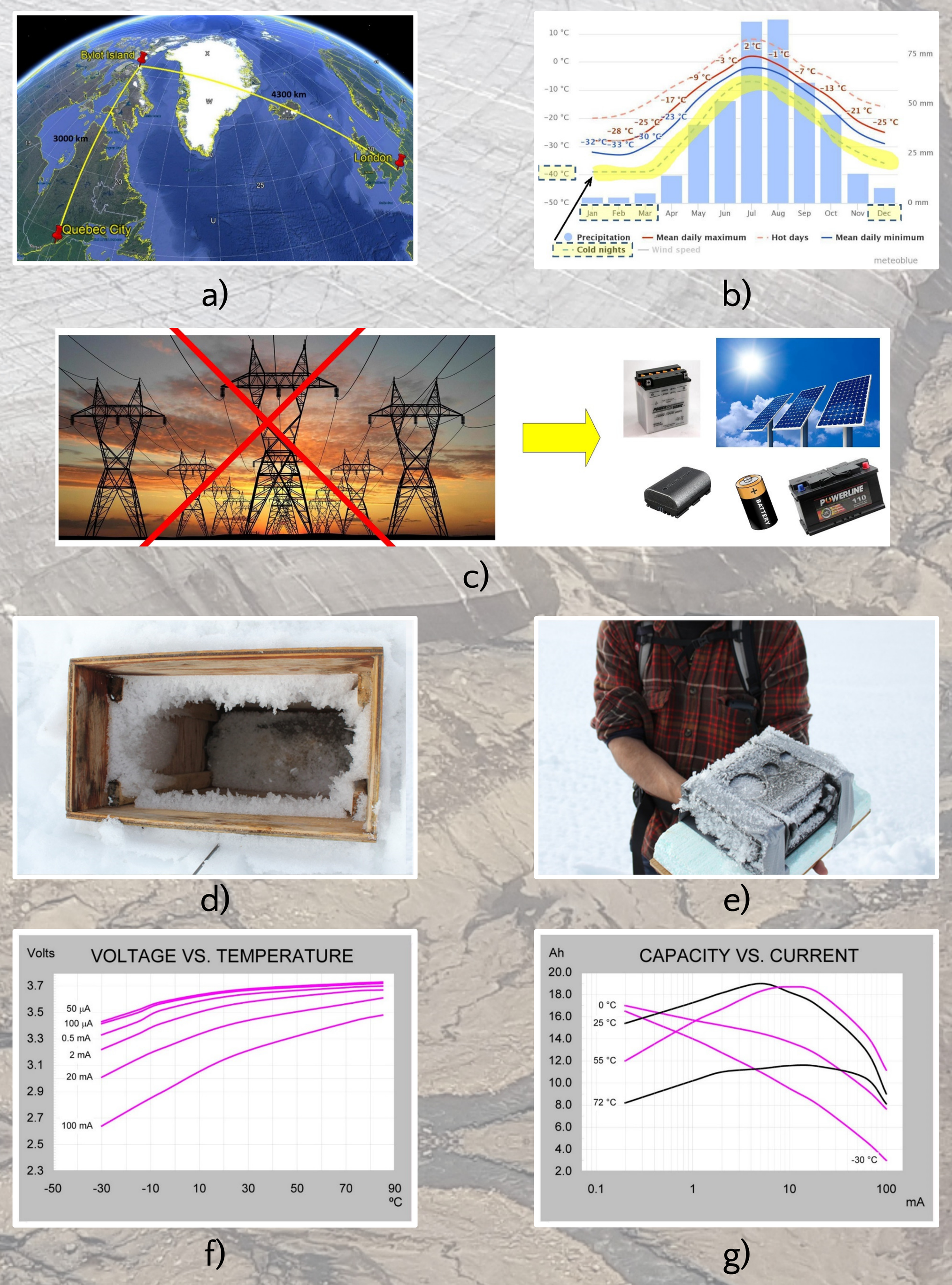

Figure 2. Research challenge.

- a) Remoteness and accessibility issue; no intervention will be possible after installing equipment for the entire recording season (August–May) → robustness and autonomy.
- b) Very low ambient temperatures (with a minimum about -40 C for 4 months) → components with military operation temperature.
- c) No power grid & lack of electrical power → low power consumption.
- d–e) frost issue → should be resolved to be able to record videos.
- f–g) negative impact of low temperatures on battery performance → limits choice of battery selection & batteries with 2–3 times higher capacity are required.

Proposed System

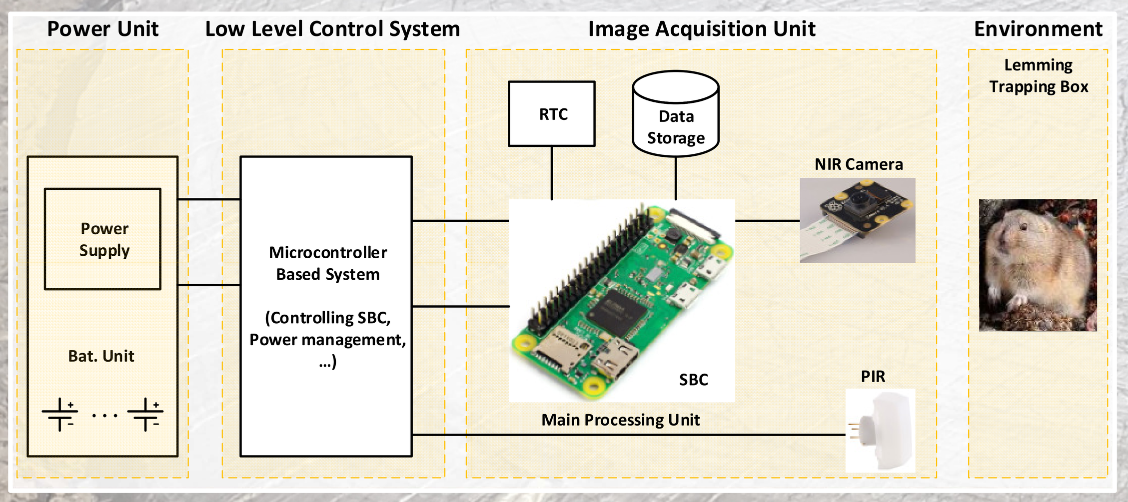

Figure 4. System Overview

Implementation & Results

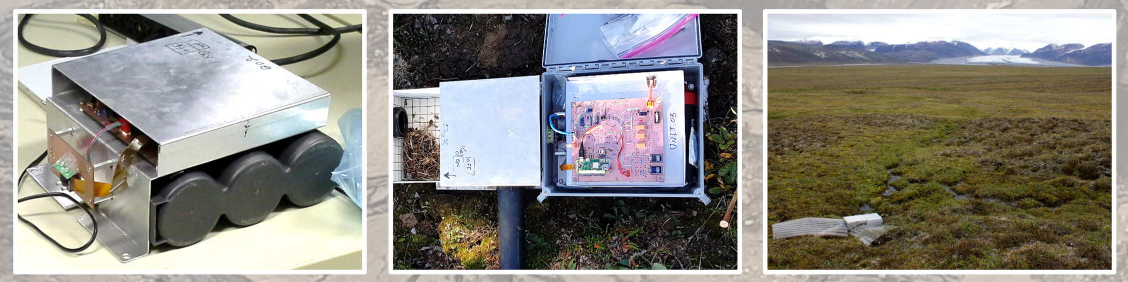

Figure 5. Equipment development & installation (Jun.-Aug. 2018).

Figure 6. Retrieval process in late May 2019.

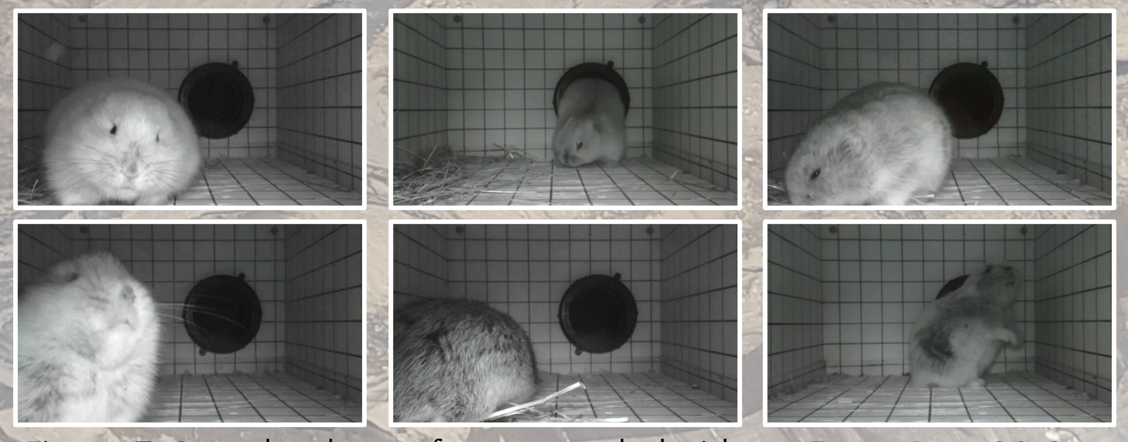

Figure 7. Sample photos from recorded videos. From Aug. 2018 to Jun. 2019 around 500 vides were recorded by 3 units of our system.

To the best of our knowledge, these are the first ever videos of lemming that have been recorded under snow in winter in the Arctic.

Result highlight:

- This is the first time an electronic equipment records videos of lemming under snow in the Arctic.
- Our new box design and camera configuration significantly minimized frost formation on lenses in winter.
- Owing to a good filming view, recorded videos contain very useful information.
- All 3 units worked throughout the entire recording season without any failure.
- The videos contain very valuable information and can be used for extracting data such as how many species of lemmings exist in Bylot Island; size, shape and color of each species; even details such as size and shape of tail and whiskers; estimating lemming population during all months of winter

Conclusion

- Results obtained within the first recording season revealed the power and usefulness of the proposed system in assisting animal ecologists to study lemming in a condition which was not possible before.
- We believe utilizing this system and similar attempts will eventually lead to a revolution in the study of subnivean ecology of the Arctic in near future.
- Biological findings will be reported in our future publications.
- Different aspects of our system require improvement. In future works, we will enhance the quality of videos, improve the efficiency and robustness of the system.

Physical Basis

The **emissivity** shows the effectiveness of thermal radiation emitted from an object surface. The wavelength of the maximum intensity (in micrometer) is computed using Wien's equation

$$\lambda_{max} = \frac{b}{T}$$

- b=2897 $\mu m K^{-1}$ is the Wien's displacement constant
- T is temperature in kelvin

The distribution of radiation spectrum is best described by Plank's law:

$$L_\lambda(\lambda, T) = \varepsilon \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

- L_λ (W. sr^{-1}\$. m^{-3}\$)is spectral radiance per unit wavelength λ at temperature T (in kelvin) per unit surface per unit solid angle
- h=6.62607004 $\times 10^{-34} m^2.kg.s^{-1}$ or J.s is the Planck constant
- c=2.99792458 $\times 10^{8} m.s^{-1}$ is the speed of light in the medium
- k_B=1.38064852 $\times 10^{-23} J.K^{-1}$ is the Boltzmann constant

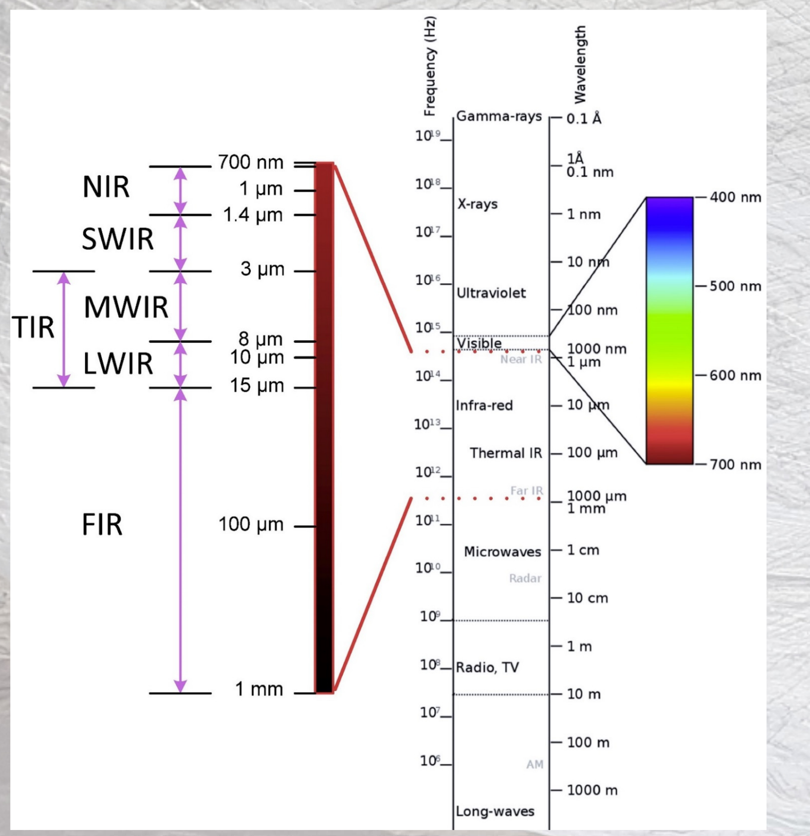

Figure 3. Infrared in Electromagnetic Spectrum. NIR: Near-Infrared,.

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Funding

This research was supported by the Sentinel North program of Université Laval, funded by the Canada First Research Excellence Fund, the Natural Science and Engineering Research Council of Canada, the Network of Center of Excellence ArcticNet, Polar Knowledge Canada and the Polar Continental Shelf Program of Natural Resources Canada.

Acknowledgements

Figure 2a was drawn using Google Earth; Graph in Figure 2b was provided by https://www.meteoblue.com/en/weather/forecast; Figures 2d–e were provided by Prof. Gilles Gauthier; Figures 2f–g were taken from TADIRAN Lithium Battery Data Sheet Model TL-5930 at http://www.tadiranbat.com/assets/tl-5930.pdf