Monitoring Glacial Advance and Retreat of the Skaftafellsjökull Glacier, Iceland

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Abstract- **Visual documentation of glaciers can provide daily, seasonal, and yearly statistics concerning their advance and retreat, as well as contribute to historical record. Recognizing how glaciers change will improve glacier models, which leads to a better understanding of climate and ice-sheet interactions. Obtaining frequent images of glaciers can be difficult since they are often located in remote locations with rugged terrain and harsh weather conditions. Access can be arduous even during warm weather months. To overcome this obstacle, we propose building an autonomous imaging device that is powered by solar panels and can withstand the harsh weather. The imaging device will have the ability to capture images of the glacier at specified times, store them for uploading, and send them over a radio link to an Internet access point. Then they will be sent back to Penn State for analysis and display at the Earth and Mineral Sciences Museum. The autonomous imaging system will contain a high-resolution digital camera, a low power Linux computer, used for the command and control of the camera, and a radio to communicate with the Internet access point. The system will be accommodated in an all-weather case designed specifically for this application.**

I. INTRODUCTION

Due to the harsh weather conditions of the Skaftafellsjökull Glacier, an imaging device is necessary to assist in the documentation of the recession and advancement of the glacier. Glaciers change size in response to both short-term weather conditions as well as long-term trends in climate. Attribution of glacier mass change due to global climate change versus local variations in weather requires a long-term archive of glacier position and shape. Images taken of glaciers decades ago, and as much as one hundred years ago, are being compared to recently acquired photographs.

The visualization of the Skaftafellsjökull glacier will be documented with the aid of a programmed digital camera that serves to capture images of the landscape. The Nikon D50 SLR digital camera is the camera used throughout this project. The Nikon D50 SLR was programmed using an attached ts7300 Linux-based single-board computer [www.embeddedarm.com]. The board collected all the captured images and stored them onto its flash-drive for further usage. To assist in the storage and automatic image capturing performed by the digital camera, the software package gPhoto2 was installed to the Linux board [www.gphoto.org]. Next, we wrote a set of custom scripts that ran periodically to capture photographs and archive them.

An all-weather case for the camera had to be constructed in order to provide the device with protection and power when out in the field. The picture feedback was required to have protection also, so silica packs were placed in the case to prevent moisture build-up on the camera lens.

II. BACKGROUND

The Center for Remote Sensing of Ice Sheets (CReSIS) Science and Technology Center was established by the National Science Foundation (NSF) in 2005. The headquarters for CReSIS is located at the University of Kansas in Lawrence, KS. The main focus of the CReSIS program is to understand and predict the role of polar ice sheets in sea level change using computer models and new technologies. There are five additional university partner sites that include Elizabeth City State University, Haskell Indian Nations University, The Ohio State University, the Pennsylvania State University, and the University of Maine.

The Penn State Ice and Climate Research Program focuses on research projects relating to glaciology, seismology, modeling, and climatology. The mission of this research program is to unite Penn State's polar researchers and encourage new projects. The Penn State Ice and Climate Research Program also aims to establish a vibrant and dynamic web presence for Polar studies at Penn State University, and act as an interface to the CReSIS Science and Technology Center.

The Skaftafellsjökull Glacier, Iceland, located at 64.050° latitude and -16.883° longitude, was first explored in 1754. The glacier sits 1446 meters above sea level.

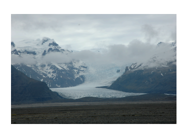

Fig. 1. The Skaftafellsjökull Glacier.

The icecap that Skaftafellsjökull is situated on overlies an active volcano that has experienced numerous eruptions over the past 800,000 years, and continues to erupt periodically.

The extraction, installation, and programming of the digital camera are controlled using a ts7300 Linux based system. Linux is the name given to any "Unix-like" computer operating system that uses the Linux kernel. The system's utilities and libraries usually come from the GNU operating system that provides free and open-source software for its users [www.fsf.org]. This operating system is used for a wide variety of computer hardware, video game systems, arcade games, and embedded devices.

GPhoto2 is the successor for the image-capturing software gPhoto. GPhoto2 retrieves captured images from cameras and has the ability to transmit the images to remote computers [www.gphoto.org].

III. METHODOLOGY

The first step in setting up the automated capturing device was to establish all necessary files and folders on the Linux board. The Linux board used in this project was a ts7300 powered by 12V DC, which was provided by a power supply during testing, but will be replaced by a 12V battery during operation. Communication between the ts7300 and its user was established by connecting the board to the user's computer using an Ethernet connection. Once the ts7300 was powered and connected, we open a terminal on the ts7300, which served as a workplace for the commands and logic behind the project. The user must log on to the Linux board by typing "ssh root@192.168.0.51" and the root password. While logged on as root, the user is able to perform more functions, such as deleting and downloading files, that other users do not have the capability of doing. To list the files and contents on the ts7300, we use the "ls" command. To store the images, a separate directory called "Images," was required to be made by using the "mkdir" command followed by the name of the directory, in the home shell. The shell script used to operate gPhoto2 and crontab was created by using the vi editor. To set up the vi editor, the user types "vi" at the command line in the home shell, followed by the name of the script that is being created.

The next step was downloading and unzipping the installation files of GPhoto2 onto the Linux board. The gPhoto2 software required all files to be unzipped and working properly before connecting the digital camera to the Linux board. After obtaining the list of over seven hundred and thirty compatible cameras, the Nikon D50 SLR camera was chosen after further comparing its dimensions, number of mega pixels used per frame, and reliability to other camera options.

The gPhoto2 command line interface was required to monitor and complete the captured imaging process of the digital camera. The first command, "gPhoto2 --list-ports," checked and listed all active ports of the ts7300 for the user. The digital camera was connected to the ts7300 by using a universal serial bus better known as an USB cord. Once connected, the digital camera was powered on using the on or off switch located on the camera. Although the camera may be connected to the Linux board, it is possible that gPhoto2 may not be able to establish a connection between itself and the camera. Using the command, "gPhoto2 --auto-detect", the connected camera was located, listing its name and which port it was connected to. The command, "gPhoto2 --summary" provides the user with additional information and memory listings about the camera. As the digital camera was required to capture and store images at certain intervals, it was necessary for the Linux board to periodically remove images to make room for new ones. This was done by adding an "rm" line to the gPhoto2 shell script.

IV. PRELIMINARY FINDINGS

The autonomous image-capturing device was successful at capturing, uploading, and removing photographs from its central memory to the ts7300 Linux board. The Nikon D50 SLR camera took numerous photographs over the specified time and the images were successfully transferred to the Linux board. For experimentation purposes, the Nikon D50 was programmed to capture images every minute for an entire hour to determine whether or not the program was functioning properly. Crontab was used instead of manual prompting to keep the system autonomous. To accommodate the number of megabits used per captured image, a script had to be created that deleted the older images as additional photographs were taken and uploaded.

Compared to the latest digital camera models, older cameras have a larger compatibility rate with the gPhoto2 software package. The majority of the camera's listed on the gPhoto2 webpage were a balance of both new and old digital cameras, but when testing the devices, the older cameras responded to the program. It was concluded that the list of compatible cameras gPhoto2 gave on the Linux board was not accurate.

V. DISCUSSION

There were numerous obstacles encountered initially and throughout the duration of this project. If given the opportunity to reconstruct the project, we would do a few things differently. Foremost, we would use a newer version of gPhoto2. In the beginning we thought we had downloaded the latest version of the gPhoto2 software, but as time progressed, we realized we had been mistaken. Not having the most recent software on our Linux board limited the number of cameras that were compatible with the software. After we realized our error and tried to download the updated software, we were not able to because of the size of the new files and the length of time it took the files to be transported to the Linux board. When we used a Linux board that had more memory, the new version of gPhoto2 was downloaded, but the cameras the website mentioned to be compatible were not. In all, we would try to locate a program that is more reliable and capable of performing all the functions we need.

The ts7300 Linux board was easy to use and understand, but the Unix style programming required for the Linux board was extremely fastidious. Everything had to be perfect in regards to spacing and structure, but the lack of sources that demonstrated the appropriate format made Unix difficult. Many days were spent trying to debug a shell script whose only error was an additional space. In addition to possibly using another script writing program, such as the Emacs editor, we would like a Linux board that has more memory so that more photographs can be taken and stored. The limited amount of memory drastically restricted the number of photographs that could be retained

VI. APPENDIX

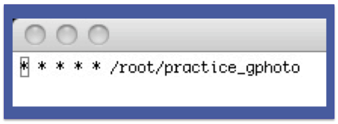

Fig.2 Crontab script

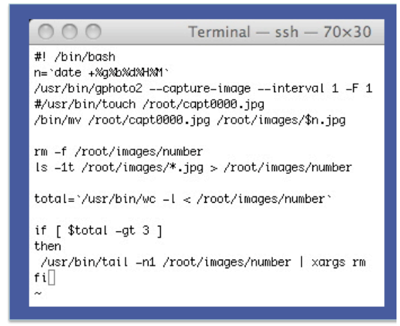

Fig.3 gPhoto2 scrip

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