EE301: Final Report

The Earth's Magnetic Field: This lecture was given by Prof Tony Fraser-Smith on the current state of research on the Earth's magnetic field. To summarize, he started the lecture by discussing how the Earth's magnetic field can be viewed as a large magnetic dipole. He continued by talking about the implications that this has such as the shielding it provides the Earth from solar wind. He discussed the history of the switching of Earth's magnetic poles. This phenomenon is interesting because the mechanism for pole reversal is not well understood. The direction and strength of the magnetic field over time can be measured through magnetic minerals. The minerals have permanent magnetic moments and based on the time they were formed and the direction of the magnetic field, the Earth's magnetic field direction can be determined for that time period.

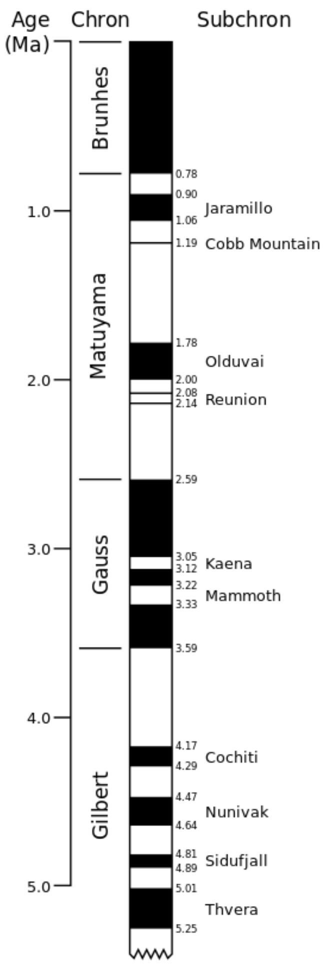

Figure 1: History of the Earth's Magnetic Field

One of the figures Prof Fraser-Smith provided is on the left. It depicts the direction of Earth's magnetic field over time and as one can see, it seems to very random. The direction of the Earth's magnetic field was determined by observing magnetic minerals as mentioned above. We are currently in what is called the Brunhes era which we have been in for the past 780,000 years. Black periods are times where the magnetic field matched the polarity that we observe today. We have been a relatively long period of magnetic field stability which leads to the idea that we are due for a magnetic pole reversal sometime in the near future, however the time of the next magnetic field change is difficult to predict. Since the time scale between these changes is on the order of 10,000's of years, it is difficult to determine whether a magnetic shift will happen soon. The strength of the magnetic field is currently decreasing and according to Prof Fraser-Smith's estimate based on current data predicts that the Earth's magnetic field would not decay to zero until year 3797. He admits that this prediction will likely not be correct, however the timescale it provides is short compared to previous field reversals.

Finally, Prof Fraser-Smith discussed the models used to represent the Earth's magnetic dipole and some of the research he has done in this area. Previously, the magnetic field was modeled using what is a called a center dipole model. Prof Fraser-Smith's research in the eccentric dipole model has shown that a more accurate description of the Earth's magnetic field can be obtained using this model instead of the center dipole model which was previously widely used in the field of magnetospheric studies.

I found his lecture interesting because it seemed strange to think that the Earth's magnetic field is not something that is well understood since it seems to be a very basic and easily measured aspect of the fields measured around Earth. Coupling the ease of measurement with Maxwell's equations which completely describe electromagnetic fields, it seems that the Earth's magnetic field would be able to be easily described. However, this presentation was able to show that current models of the geodynamo are unable to predict the measured fields found at or above the Earth's surface. Possible avenues for further research include simulation and use of the larger amount of data recently available on the Earth's magnetic field collected from satellites.

Human's are awesome (lossy image compressors): This talk was given by Prof Tsachy Weissman on how techniques that human's use for image compression could be relevant to the way that images are stored in the future. He starts the talk by summarizing the current best approaches to image compression (JPEG is the current standard, however WebP by Google is the current best). He then continues to talk about information theory and a study be Claude Shannon where Shannon had research participants guess the next letter in a text document based on the previous letters found in the text document. What he finds is that each letter in the document on average only requires around 2 bits of information. This theoretical amount of compression which humans were able to achieve was only recently overtaken by AI at Google in the mid 2000's. Prof Weissman then explains how similar methodology could be used to determine how much information is actually contained in a photograph.

To evaluate the amount of information needed by humans to recreate an image, he uses a group of high school students communicating over text chat. One student is given the role of the encoder or describer and the other student is given the role of decoder or recreator of the image. The encoder will send messages and links to describe the image to the decoder, whose job is to then recreate the image. The encoder can see the image as it is being recreated and offer additional information as the image is created. This may seem impossible from the perspective of encoding and decoding, however it makes sense in an actual system since an encoder knows all of the information it has previously sent to the decoder and can also simulate the decoder state up to its current point, thus allowing the encoder to view the current state of the decoded image and create new inputs based on the currently decoded state. Using this method, the students are able to create fairly accurate recreations of certain images. The text file of their chat log is then compressed using lossless compression and the size of this file is considered the amount of information needed to encode the image.

Figure 2: (Left) Student creation (Center) Original (Right) WebP

The image the students created is then compared to a similarly or slightly larger WebP image. An example of the original in comparison with the two images is provided in figure 2 above. Participants in a separate study were then given a series of these image triplets and asked to compare their satisfaction rating between the student and WebP compressed images. The survey data showed that participants were more satisfied with the students recreated images than the WebP compressions of similar size. The conclusion to this study is that further image compression is possible using techniques more closely resembling that of a human.

This study is very interesting since it shows that there is potentially much more compression possible for a given image over present techniques. To further this study, I would examine the minimum number of canonical images needed to recreate a statistically significant number of photos. I would also try to use a certain number of textures, edge detection, and color matching to see if using a sort of patchwork technique could further reduce the size of images under compression.