Using ground penetrating radar to localize buried beaver holes

1. The problem and motivation

Beavers dig holes in dikes and dams to build an opening tunnel to their nest. This can cause damage and has risks. Because people in the water board wants to kill beavers as the last option, they frequently monitor the dikes and dams to find and fill up the beaver holes (Figure 1). The current method for localizing the holes is to scan river and water body banks using sonar sensors mounted on the boats. Although this method is effective to localize the potential holes, it is a human-intensive, time-consuming, and expensive procedure. Thus, evaluating alternative methods that can potentially localize buried beaver holes is a necessity.

Figure 1. The corridor of beavers is excavated and filled up several times in the year.

2. Drone-based Ground penetrating radar

Signals of disturbance of land sub-surface are invisible at beaver holes. In this respect, Ground Penetrating Radar (GPR) is the most common technology which is used to explore land sub-surface disturbance (Figure 2). GPR uses radar pulses (UHF/VHF frequencies) to image the subsurface by recording and processing the reflected signals from subsurface structures. The calculation and comparison of dielectric constant highlight the location of sub-surface disturbance because the constant is substantially different compared to the vicinity area. We have tested the GPR system on the drone (Figure 3).

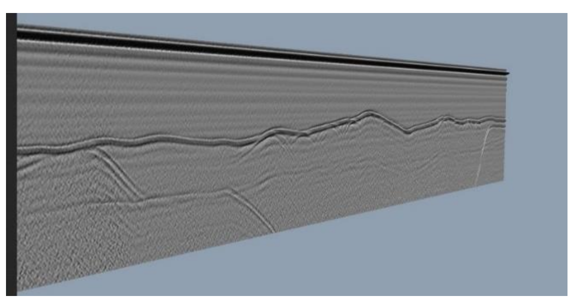

Figure 2. Sample GPR information that image the ground sub-surface layers.

Figure 3. The GPR system mounted on DJI M600 drone.

3. Test site and flight settings

To test the drone-based GPR, we selected one beaver hole that was detected by water board Hunze en Aa's in De Hunze river. We flew over the hole location alongside the river 3 times with 1 m/s as flying speed and ~ 2 m as flying high (Figure 4). The frequency of the GPR antenna was set to 200, 400, and 800 MHz and GPR sampling frequency was set to 10 Hz. Wet clay was introduced as the subsurface material for data processing.

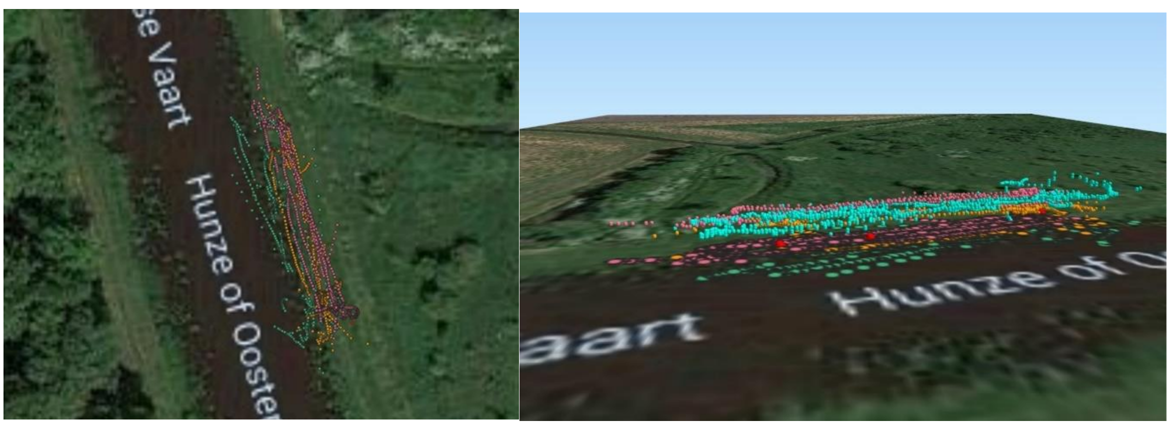

Figure 4. Location of collected GPR samples colored based on the flight number.

4. Results

During the flight scan, we demonstrated the real-time collection and visualization of GPR data using our drone system. Figure 5 shows the screenshot of the mobile application for monitoring the GPR data. The preprocessing of the collected data showed a potential location where the distribution in soil existed. However, this location is not exactly matching the reported location of the hole, almost 5 meters far from the hole location. This could be because of a few numbers of reasons: 1) GPS accuracy was not enough as the hole was very close to trees that can interfere GPS data, 2) the identified soil disturbance was not because of beaver holes.

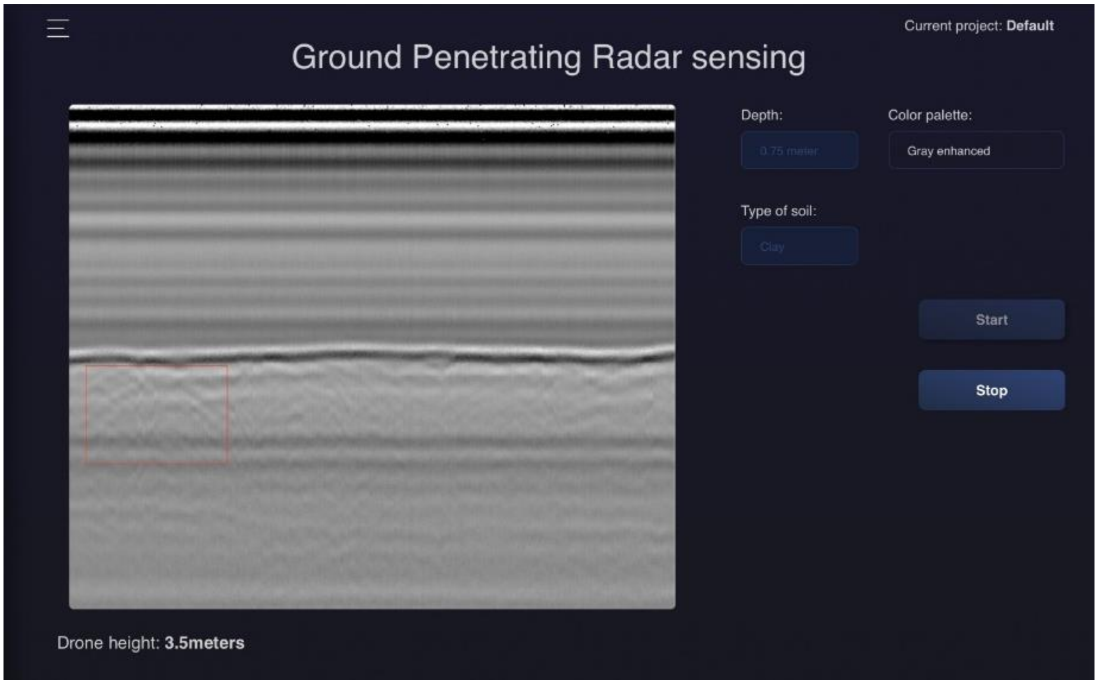

Figure 5. The mobile app for real time collection and visualization of drone based GPR system.

5. Conclusion

Although the localized soil disturbance was not matching the location of beaver hole, the potential of drone based GPR needs test further by:

- sampling GPR data at higher frequency (now it is possible to sample at 80 Hz) to make sure the resolution of GPR data is high enough to capture the width of beaver holes
- considering high variation in moisture content and soil type in post-processing of data (this reported by water board after excavating the hole location).
- flying over a site with no tree mask to make sure that GPS data is accurate.
- researching the effect of the mixture of soil and water on the reflection of GPR signals as the beaver tunnels might be underwater with various proportions of water and soil.