Ice Layer Detection from RADAR Depth Sounder Data using Novel Approach based on theory of Electrostatics

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Abstract-

In recent years global warming has caused serious damage to our environment. Accelerated loss of ice from Greenland and Antarctica has been observed in recent decades. The melting of polar ice sheets and mountain glaciers has a considerable influence on sea level rise and altering ocean currents, potentially leading to the flooding of the coastal regions and putting millions of people around the world at risk.

The Rradar depth sounder is an important instrument that can provide relevant information about changes to polar ice sheets. Ice thickness can be determined by distinguishing layers of different dielectric constants such as air, ice, and rock in radar echograms. Ice layer identification in radar echogram cross section images facilitates three-dimensional modeling of ice layers and subsurface bedrock. Manual layer identification is very time consuming and is not practical for regular, long-term ice-sheet monitoring. The development of automated techniques is thus fundamental for proper data management.

This paper proposes a novel approach to ice layer detection, using electrostatic force. According to Coulomb's law, *the magnitude of the electrostatic force between two charged particles is directly proportional to the scalar multiplication of the magnitudes of charges and inversely proportional to the square of the distances between them.* In our proposed method, every pixel is assumed to be an electrically charged particle which has electrostatic interaction with other neighboring particles/pixels. The electrical charge of each particle is represented indirectly by the grayscale intensity of the pixel. In fact because pixel signs are always positive, the electrostatic force between them would be repulsive. To have both repulsive and attractive force between pixels, in the first step, pixels are transformed so that they have small values with positive and negative sign. In the next step, the electrostatic forces a pixel exerts on every other pixel around it are computed using Coulomb's law. Finally the vector sum of all electrostatic forces is used to calculate the magnitude of signal variation. Borders between ice layers are indicated by high magnitudes of electrostatic forces. Experimental results of testing on publicly available radar echograms of Greenland and Antarctica show promising capabilities for automatically detecting ice layers.