The HELM Project: Finding Medieval Irish People Using Drones

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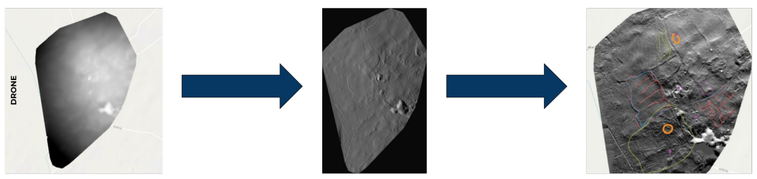
Introduction

- The Human-Environmental Exchanges in the Landscapes of Medieval Ireland (HELM) Project aims to find **archaeological features** of **medieval Irish settlements** using aerial imagery within the modern Irish landscape
- Limited research exists on where and how ordinary medieval people lived – low-lying features such as burgage plots indicate the presence of deserted settlements
- Images of 7 locations across Ireland were collected using **small unmanned aerial vehicles (UAVs)**:
  - Kilbixy, Kilmacahill, Knockainy, Ardmayle, Glenogra, Ballynahinch, & Fore
- Aerial imagery is cost effective, preserves land, and is easily scalable compared to traditional fieldwork
- 3D reconstruction produces a **Digital Terrain Model (DTM)** to model surface elevation

Aerial image of Glenogra, Ireland

Methodology

- **3 steps to identify features** based on aerial data:



Digital Terrain Model | Hillshade | Labeled Hillshade

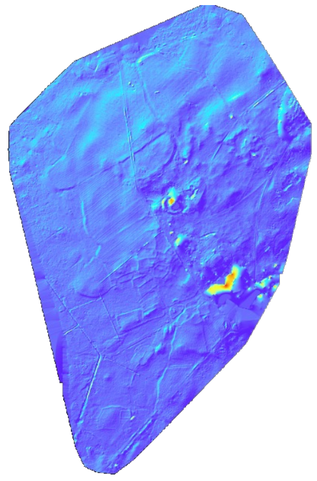
1) **Acquire DTM** - removes elevation outliers to focus on ground and sub-surface features
2) **Apply visualization techniques** to enhance topographic variability for easier feature detection
3) **Implement image segmentation model** for facilitation of detection process

DTM Analysis Techniques

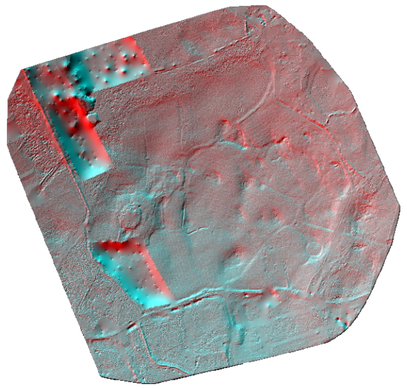
- **Six different DTM analysis techniques** performed on each site using ArcGIS and RVT software:
  - Hillshade, Composite Hillshade, Principal Components, Deviation from Mean Elevation, Difference from Mean Elevation, & Sky-View Factor
- Python script written to automate hillshade raster and JPEG creation in ArcGIS - combinations of azimuth and elevation angle customizable via a small GUI

Site Visualization

- **Multiple visualizations** are necessary to fully examine features at each site
- Hillshading typically visualizes field walls the best
  - Low-lying features stand out at 15 to 20° elevation angle
  - Multiple illumination settings are needed to reveal linear structures lying parallel to individual directions
- Burgage plots and field wall remains detected at the sites Kilbixy and Kilmacahill - near a castle or monastery



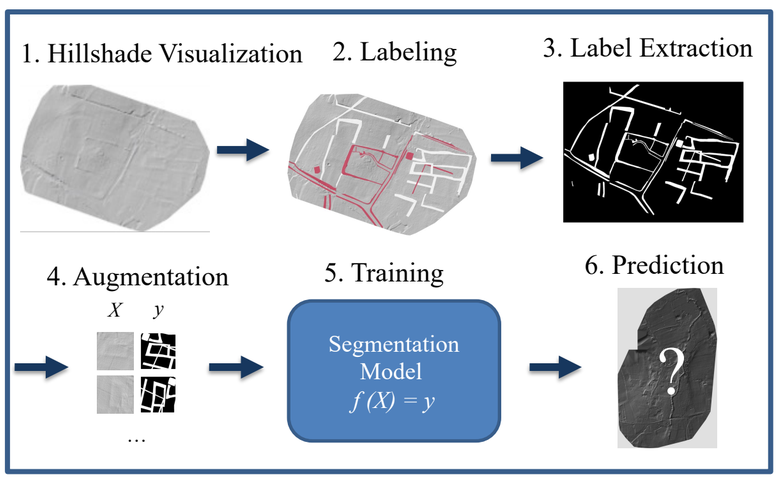
Kilbixy Hillshade from 15° NW



Kilmacahill Principal Components

Automatic Feature Detection

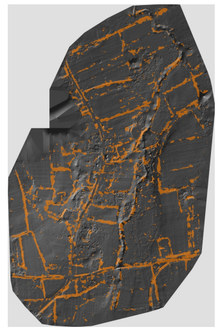
- Implemented each step of the pipeline as a Python command-line tool
- Utilized Azavea Groundwork for manual labeling
- Augmentation to increase size/diversity of training samples
- Selected **U-Net image segmentation model** with a VGG16 encoder & sigmoid activation function
- Dice loss used for training to address class imbalances



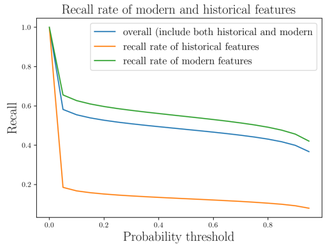
Model Results

- Training dataset of 1512 labeled images from Ardmayle and Kilbixy with testing on Knockainy
- Modern / historical features grouped together for training
- 40 Epochs -- 7×10^{-4} Learning Rate -- 0.8 Momentum
- **Precision-Recall AUC: 0.25** (baseline 0.07)

Ground Truth



Prediction
(probability threshold = 0.5)



Recall Rate vs. Probability Threshold plotted for modern & historical features

- **Model predicts most features** – best on modern features
- Pixelwise accuracy metrics may not fully encapsulate model performance
- Limited generalization ability due to site-to-site variations

Conclusions & Future Directions

- Project workflow is applicable to future geospatial methodologies and can be used by other archaeologists
- Manual labeling can be erroneous – expert archaeology knowledge is crucial when labeling targeted features
- Combining visualizations will aid labeling and training
- Model performance metrics tailored for archaeological detection applications will be more informative and other models may be more suited to the task
- Immediate next steps include training a model to distinguish between historical and modern features

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