



Project Title: Image segmentation of lightning events using machine learning

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Ethics: ☒ Request for waiver (does not involve human participants or sensitive data)
☐ Copy of ethics application attached (Non-medical) – School Committee
Supervisor Signature ☐ Copy of ethics application attached (Medical) – University Committee

Project Outline: (give a brief outline such that ethics reviewers understand what will be done, 100 words maximum)

The development of an image segmentation system to identify sets of pixels in high-speed [HS] lightning footage as lighting, sky, horizon or occluding features (such as buildings) using a machine learning approach.

Project Specification:

Machine Learning system: CNN with LSTM (multi-layered perceptron for computer vision)

The input to the system will be high-speed footage of lightning strikes from a fixed camera, with sets of pixels (super-pixels) classified as limited features at the output as meta-data or (optionally, an overlay map indicating the image segmentation visually.)

We propose extending the work in 'A Computer Vision System To Analyse Images Of Lightning Flashes' by Gin, Bianchi and Pilon (University of FEI, Brazil) to use machine learning techniques to detect and classify regions which represent semantic features (useful in future analysis) without manual region input. Ideally, the system will be a single neural network which performs pixel partitioning and mask creation along with feature classification.

After the success criteria is met, with robust and confident identification of regions of frames with and without lightning, the project could lead to a more sophisticated analysis of the frame-by-frame development of a lightning strike, with deeper classification of the direction of the flashes (VF/HF). If this is achieved, the system could be extended to detection and classification of individual components of regions of lightning (multiple stokes, leaders, etc), speed of stokes.

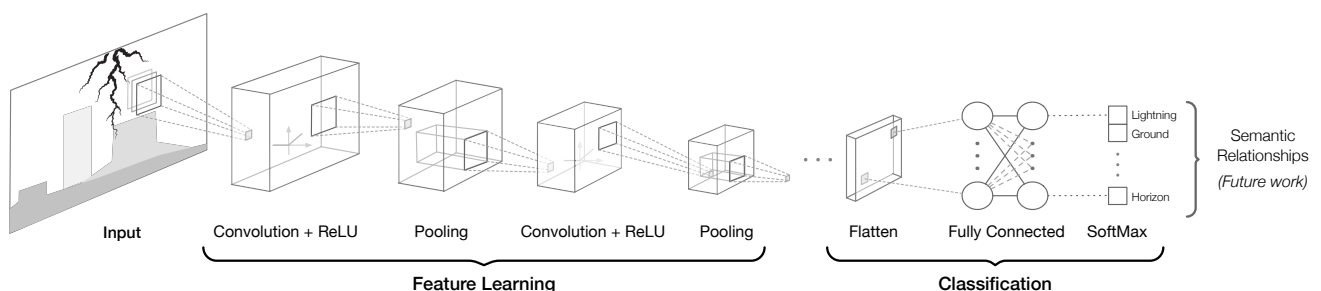


Figure 1: System Overview

Milestones:

Preliminary Budget & Resources:

<ol style="list-style-type: none">1. Research in to ML technique: CNN with LSTM /RNN, Fast-CNN, Faster-CNN2. Data accumulation/handover3. Selection of image classification network (AlexNet/VGG/ResNet)4. Initial Training5. Iteration on training/parameter adjustment6. Testing of system (iterative)7. Validation (iterative)8. Image pre-processing script development9. Establish optimal aspect ratio10. Data segmentation: Train/Test/Validation sets11. Selection of Cloud services12. Comparative testing: resolution/performance/feature classification13. Run system on all input videos14. Analysis of results15. Presentation16. Report	<ol style="list-style-type: none">1. Data<ul style="list-style-type: none">• HS video footage• Existing classification metadata2. Data storage (min 3Tb HDD)3. Crunchyard allocation4. Additional computing resources (AWS/Google/Azure) ~ \$120 [USD]<ul style="list-style-type: none">• 2 CPU/4Gb RAM : 1000hr• 4 CPU/16Gb RAM : 200hr
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Risks / Mitigation:

Failure to acquire ethical waiver: clearance not granted Mitigation: Apply for (non-human) ethical clearance on alternative data-set
Lack of sufficient data: too few videos of lightning Mitigation: supplement using images/videos from the internet marked as "labeled for reuse with modification"
Quality of data: noisy video, cropped lightning strokes Mitigation: selecting subset of available data to train and test system.
The trade-off of resolution to computing resources: pixel arrays too large Mitigation: Scaling down input videos to produce smaller input arrays
Risk of costs of computation: building/training ML (magnitudes of computational power required currently unknown) Mitigation: Initial testing, use of internal resources, restrictions on size of input data
Budget not approved: insufficient funds for external computing resources Mitigation: Use of Crunchyard → Use of personal computers (with severe restrictions on input data size)
Risk of poor performance in selected ML system: fundamental CNN structure not performing adequately Mitigation: use of existing ML structure with replacement outermost layers