WebCam Project

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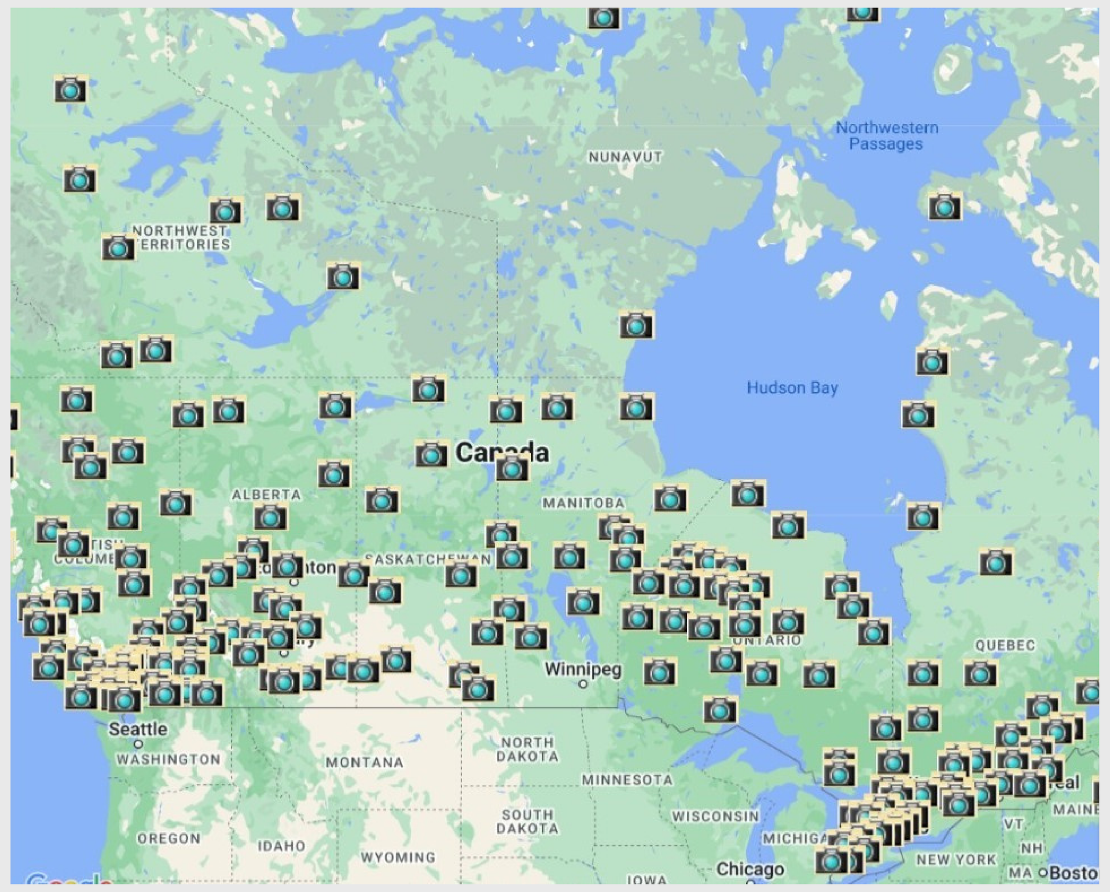
Motivation



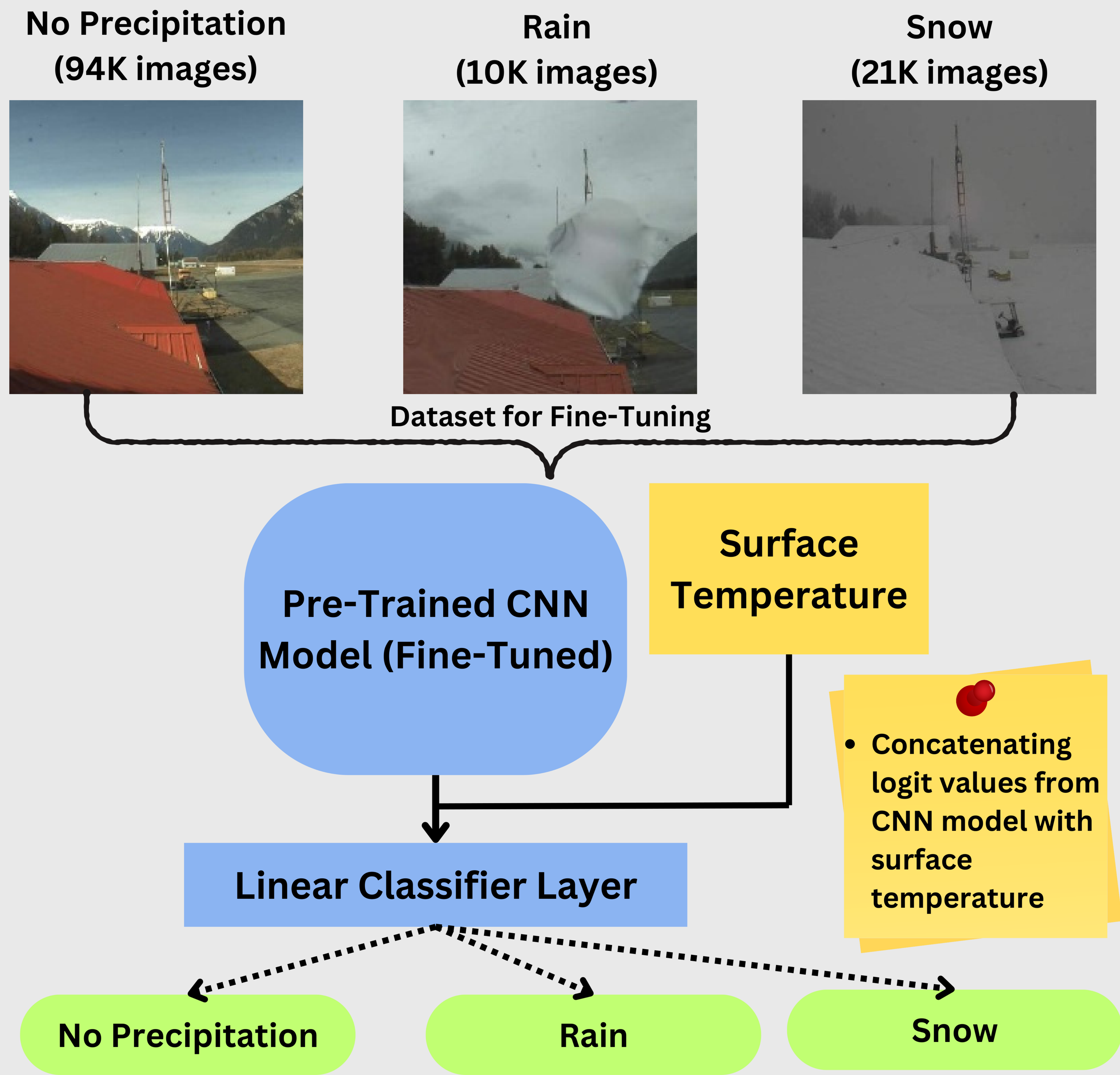
There are 10,000+ webcams around Canada used to monitor weather at airports and traffic on highways

Automating the image classification with machine learning model can have several benefits:

1. Reduced cost compared to automatic present weather sensors or manual observations
2. Ability to flag interesting images to weather forecasters for further analysis

Models & Datasets

125K images collected from 37 different NavCan locations (Dec 16, 2022 to Jan 23, 2024) were used to fine-tune the Convolutional Neural Networks (CNNs), METAR data from each NavCan location was used to match the images to observed surface temperature and precipitation type



- Concatenating logit values from CNN model with surface temperature

Training Results

4 different pre-trained CNN models (MobileNetV2, MobileNetV3, DenseNet201, Xception) were used as part of 3 different architectures (image-only, image + surface temperature (hybrid), hybrid w/t learnable weights for each component)

Hybrid architecture with DenseNet201, Xception, or MobileNetV2 models performed the best, achieving 86.4-86.87% overall accuracy. Given that MobileNetV2 runs ~5x times faster than DenseNet201 or Xception models with little performance difference, MobileNetV2 with Hybrid architecture is the most ideal

Model	Param #
MobileNetV2	3.4M
MobileNetv3	5M
DenseNet201	20.2M
Xception	22.8M

Fig 1. Parameter size of each pre-trained CNN models

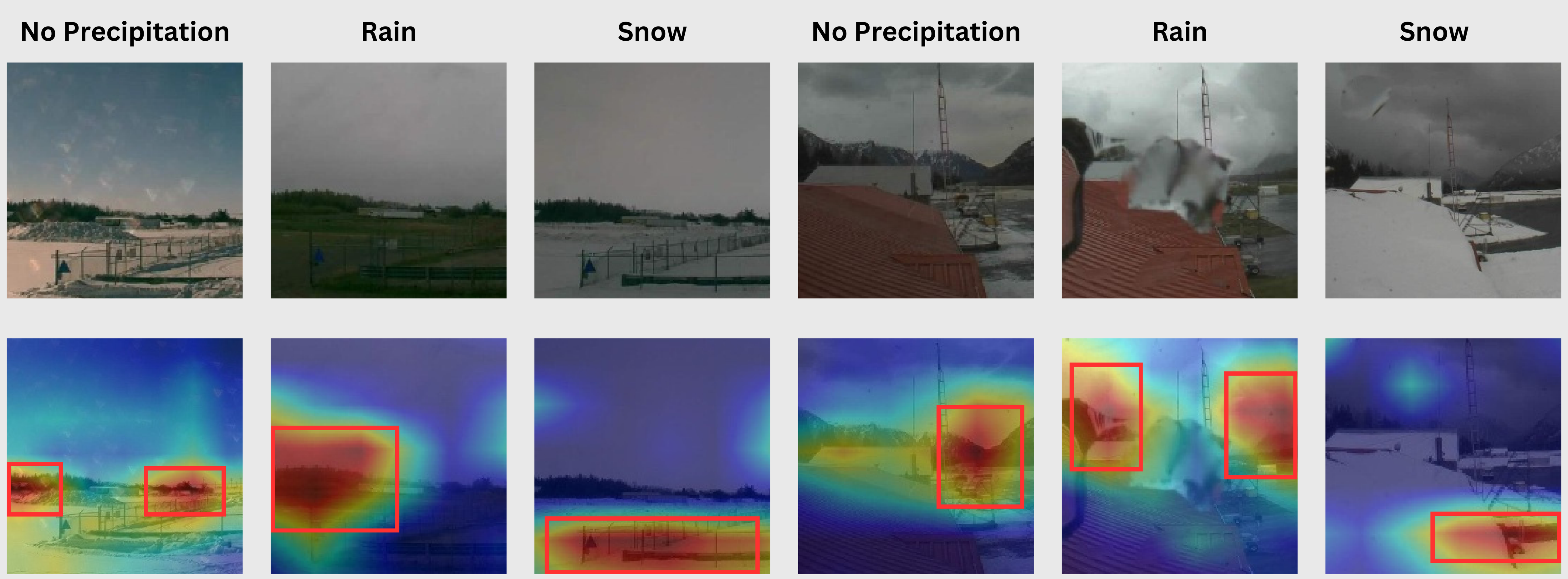
Model Name	Overall	No Precipitation	Rain	Snow
DenseNet201Hybrid	86.87	83.96	87.26	89.39
XceptionHybrid	86.55	72.73	94.46	92.46
MobileNetV2Hybrid	86.4	83.96	87.03	88.21
DenseNet201HybridWithWeights	86.01	82.78	82.31	92.92
XceptionHybridWithWeights	85.96	82.71	82.71	92.46
MobileNetV2HybridWithWeights	85.93	83.73	84.2	89.86
MobileNetV3Hybrid	84.75	81.13	85.14	87.97
MobileNetV2	84.2	85.5	82	85.1
MobileNetV3HybridWithWeights	74.37	41.98	87.26	93.87

Fig 2. Performance of each model for No Precipitation vs Rain vs Snow classification

Model Name	P(Snow/Precip) @ <= -1C	P(Rain/Precip) @ >= 3C	Avg
Actual	100	99.65	99.825
XceptionHybrid	94.51	95.99	95.25
MobileNetV3HybridWithWeights	100	88.55	94.275
DenseNet201Hybrid	92.7	87.18	89.94
DenseNet201HybridWithWeights	93.78	84.99	89.385
MobileNetV2HybridWithWeights	90	88.04	89.02
MobileNetV2Hybrid	90.54	86.96	88.75
MobileNetV3Hybrid	89.19	85.9	87.545
MobileNetV2	87.84	82.81	85.325
XceptionHybridWithWeights	85.54	66.27	75.905

Fig 3. Each model were also evaluated on conditional temperature range for probability of predicting snow or rain, which served as a preliminary check for models' accuracy on conditions where it is expected to perform well. The poor performance of image-only model served as a motivation to develop the hybrid models

Explainable AI



**Grad-CAM method was used to highlight the areas of the image that the model was most focusing on for each precipitation type*

No Precipitation
- Light focus on horizon area
- Likely due to brighter sunlight around the horizon during no precipitation

Rain
- Heavier focus above horizon
- Likely due to heavier cloud formation during rain

Snow
- Broad focus on the ground
- Likely due to relatively higher light reflection from the ground during snow event