Grad-CAM for Video and Regression Tasks

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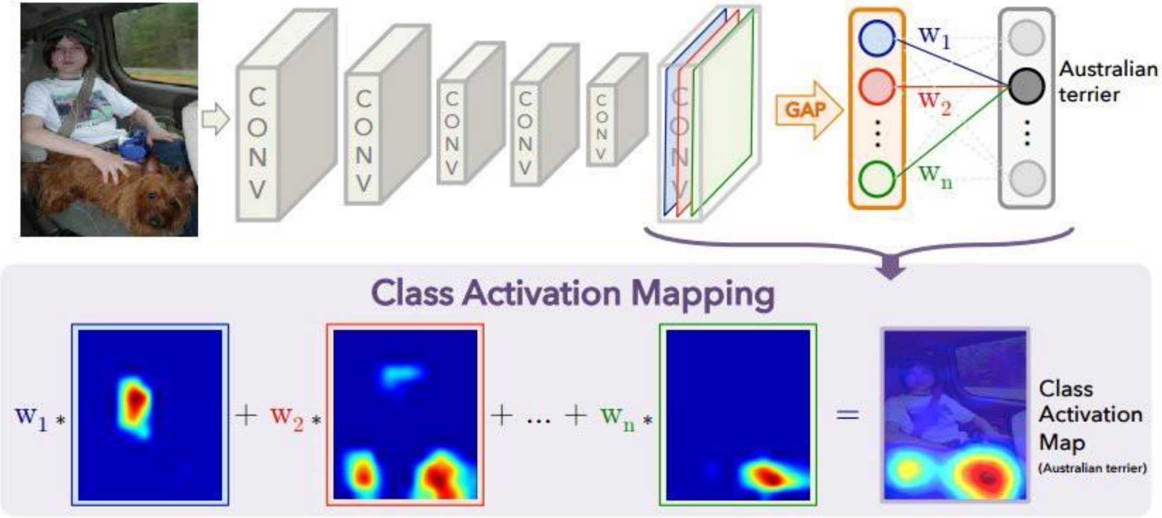
Background



Explaining the decisions of neural networks is an active are of research. This is an important topic as many applications e.g. healthcare require the explainability of neural networks

Grad-CAM is a very popular tool that is used to analyse the results of CNN for classification tasks for images.

Although Grad-CAM used a lot for images, there are not a lot of works that use Grad-Cam for videos and regression based tasks. So, in this project we explore some ways in which Grad-CAM can be applied to these tasks and show some results on these tasks.

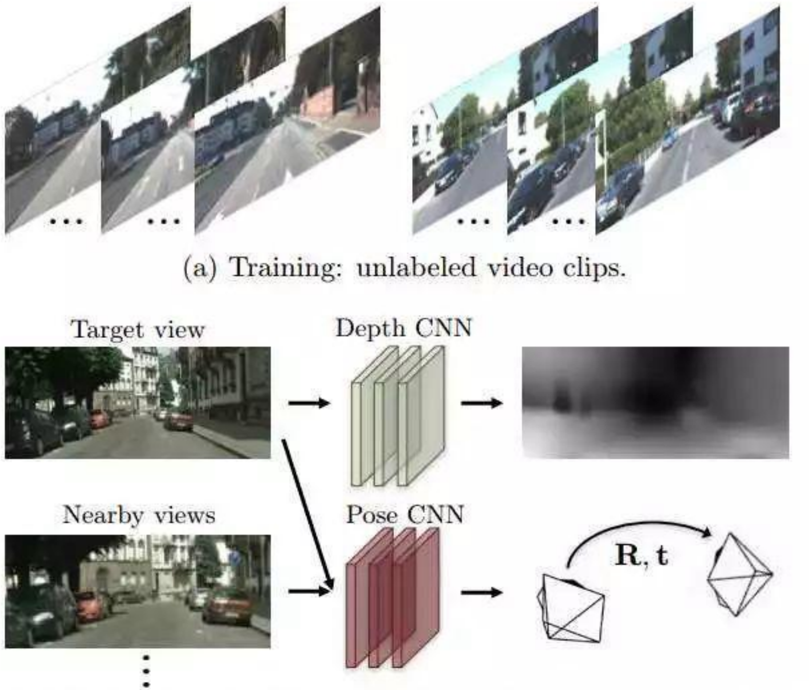
Proposed Approach

1. In this work, we apply Grad-CAM for videos using following approaches:

- We divide the video samples into equally spaced image frames which gets processed through different models
- First model is ResNet 3D which uses 3D convolution over space and time.
- Second model consists of vanilla LSTM over 2D CNN
- Third model uses LSTM over 2D CNN model with attention

2. We also propose a method for using Grad-CAM for regression. We show our results on Visual Odometry task which is an image based regression task.

Technical Details



(a) Training: unlabeled video clips.

(b) Testing: single-view depth and multi-view pose estimation.

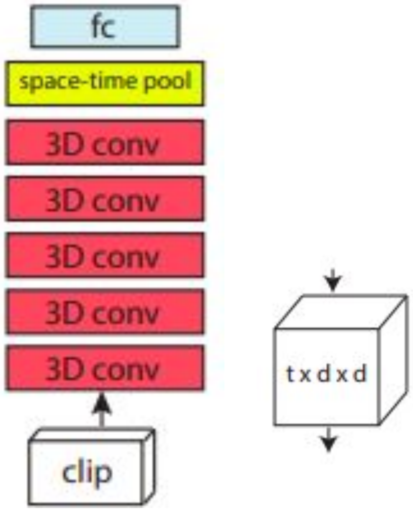
We are using SfMLearner for visual odometry task. It has 2 main components:

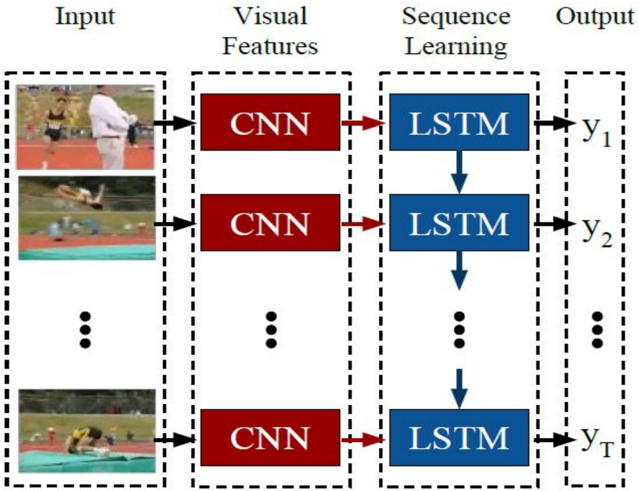
- DepthNet: predicts the depth map of the scene.
- PoseNet: predicts odometry parameter from 2 scenes.

Loss function used is based on view-synthesis.

We calculate the weights by taking the gradient of the negative loss function with respect to activation maps of the last layer for this task.

Technical Details





- ResNet does 3D convolution over both the spatial and temporal space hence one to one map from activation maps to original frame is lost
- Gradient with respect to initial layers is uniform for all pixels, hence taking gradient with respect to initial layers for one to one map is meaningless.

- Can easily map the contribution of each frame using Grad-CAM
- Multiple instances of trained CNN is needed for finding Grad-CAM for each frame, hence difficult to implement.
- Attention weights ranks the frames in order of relevance , also the Grad-CAM output on individual frames improves due to increase in accuracy.

Contributions (Novelty)

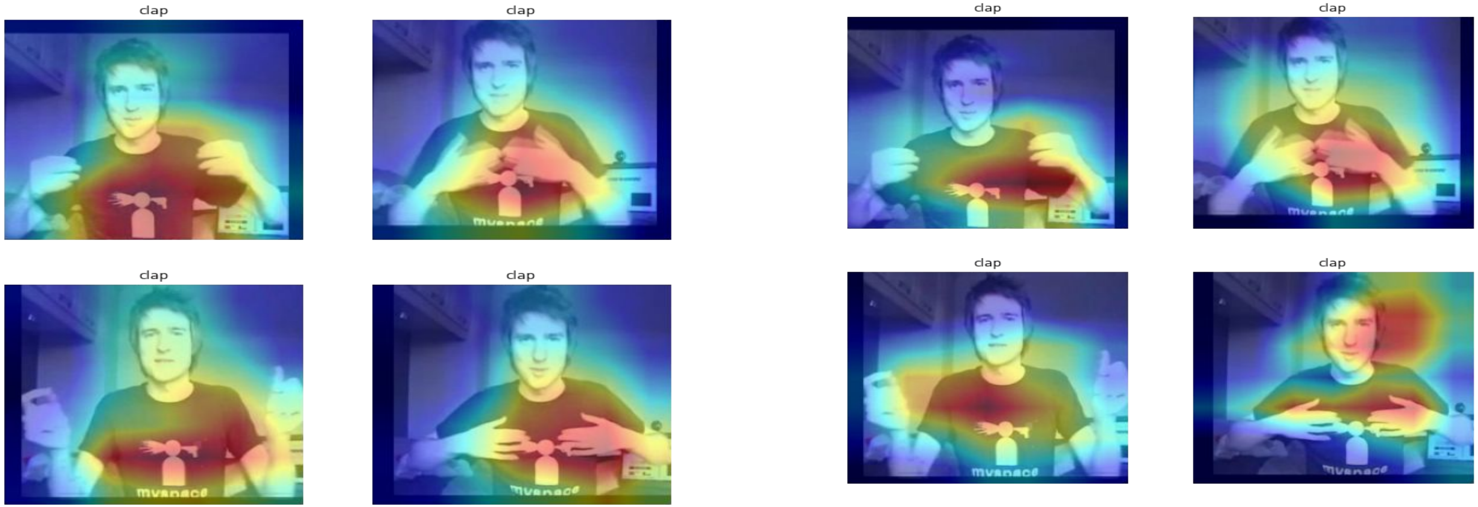
1) We have explored the use of Grad-CAM for video based classification task. We have explored 3 different models :
    - First model uses 3D convolution over time and space
    - Second uses vanilla LSTM over 2D CNN model
    - Third model uses LSTM over 2D CNN model with attention
2) We also explored Grad-CAM for regression task of monocular visual odometry by calculating the weights for activation maps using gradient of the negative of the loss function.
3) We implemented Grad-CAM from scratch for all above models and were able to draw interesting insights for both problems.

Results & Conclusion

- We observed consistent results for the video datasets as it has proven for image based datasets.
- The LSTM model with attention was able to perform better in terms of accuracy for the classification task, also the focus of the Grad-CAM improved.

- We also observed that attention weights were high for frames which contained the objects relevant for the classification task.
- The Grad-CAM with respect to different class than the ground truth are meaningful and self explanatory.
- The results for the ResNet 3D model followed the same pattern as the LSTM model results.
- Results produced by Grad-CAM on visual odometry were mostly meaningful.

Results Visualized



LSTM-CNN model with(left) and without(right) attention with respect to original class ‘Clap’

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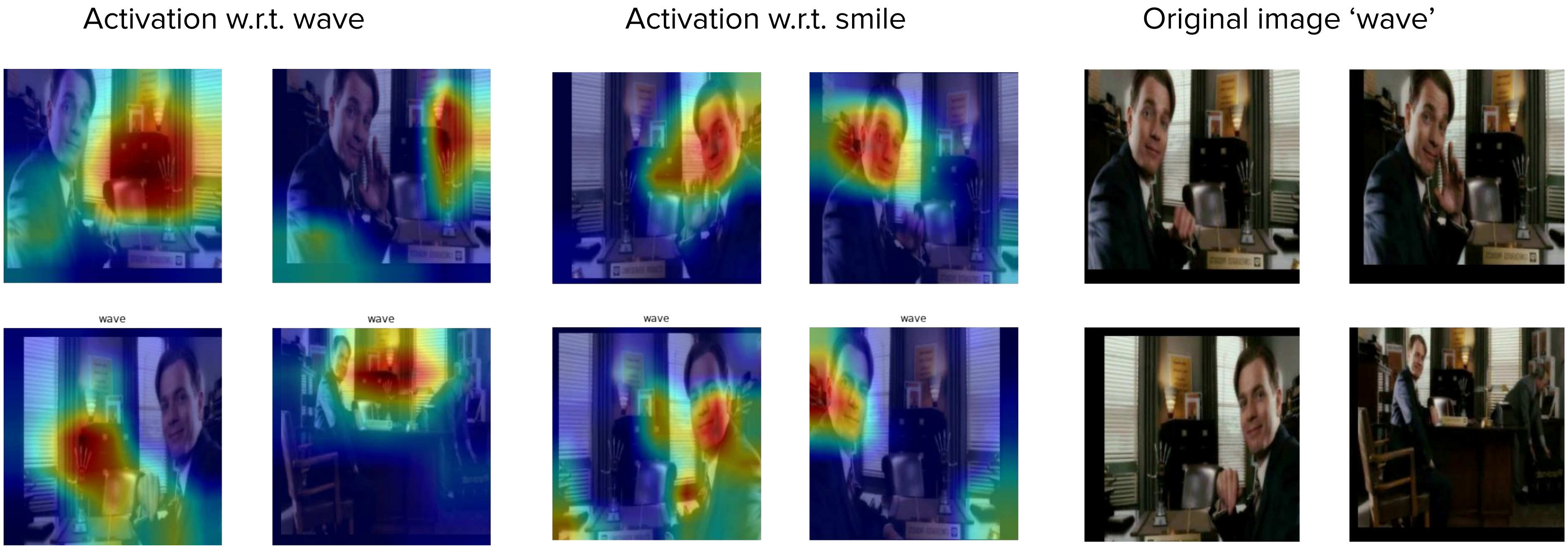

Activation w.r.t. wave

Activation w.r.t. smile

Original image ‘wave’

Grad-CAM with respect to original class ‘Wave’ and another class ‘Smile’

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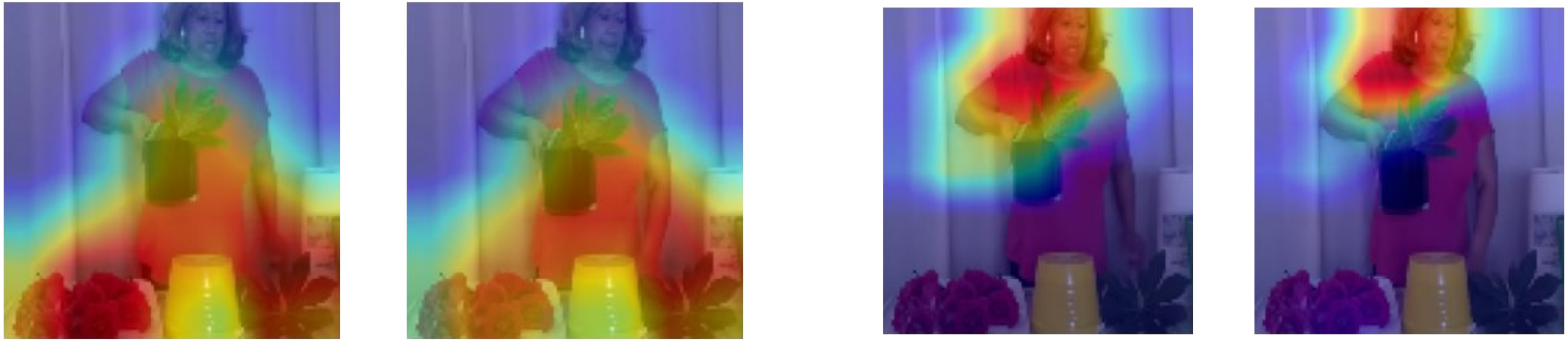

Grad-CAM results for ResNet 3D, with respect to original class ‘Arranging flower’ (left) and ‘Brushing hair’

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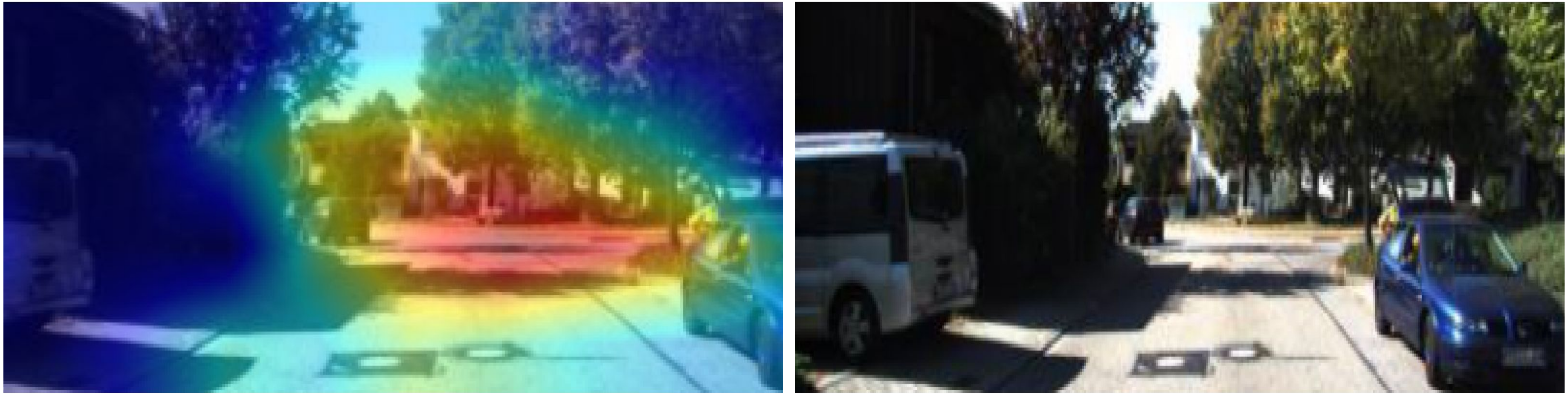

Visual Odometry: An image based regression task