Feature extraction techniques for localization of region of interest of abnormalities in biomedical image data

Presenters: Dorodi Krishty, Osazee Ero, Ludwig Wilhelm Wall

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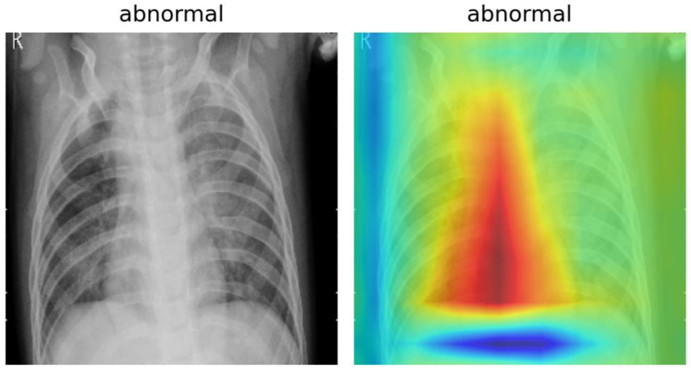
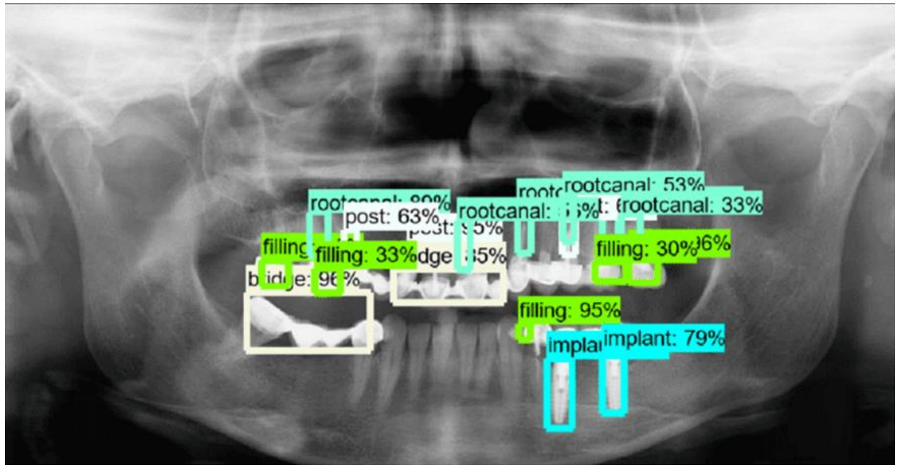
UNIVERSITY OF
WATERLOO

Motivation

An automated and efficient decision-support solution that can assist medical experts in decision making would be desirable as this would alleviate stress, decrease the chance of fatigue prone decision making and reduce patients’ results wait time.

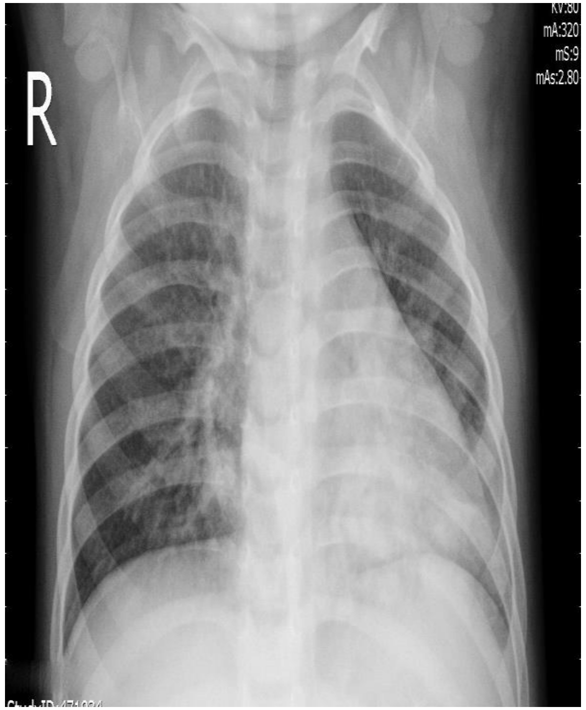


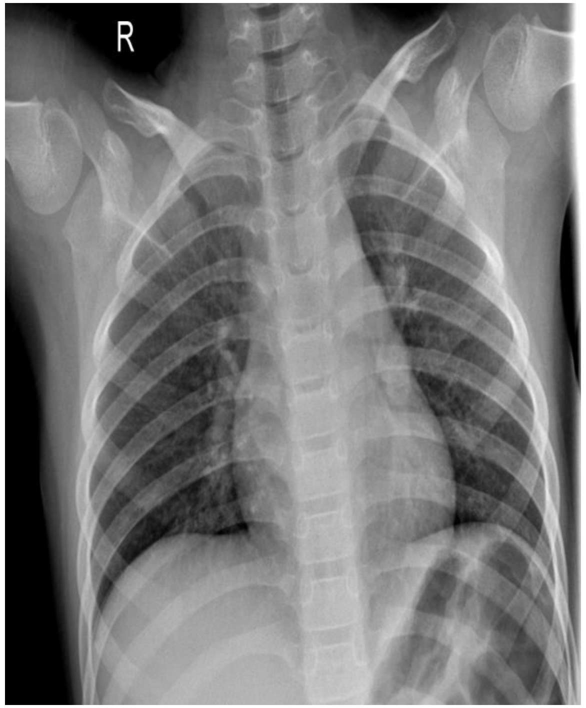


Dataset

Description of Dataset

- 5800 + chest x-ray image
- Healthy vs. Pneumonia affected patients
- Infected by virus and bacteria (SARS, Streptococcus, ARDS, Corona).





Source: https://www.kaggle.com/praveengovi/coronahack-chest-xraydataset

Techniques

1. Oriented FAST and Rotated BRIEF (ORB) with SVM
2. Weakly supervised feature localization with CNN
3. Autoencoder CNN

ORB/SVM

Technique 1

Training Stage

ORB (ORIENTED FAST & ROTATED BRIEF)

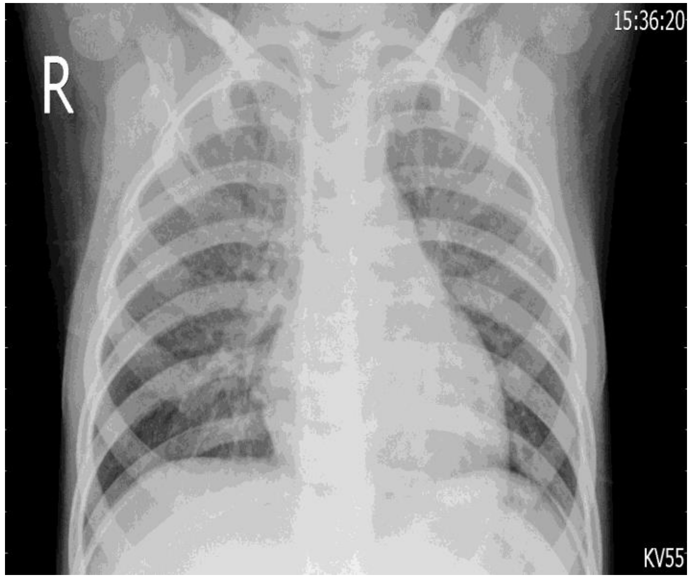
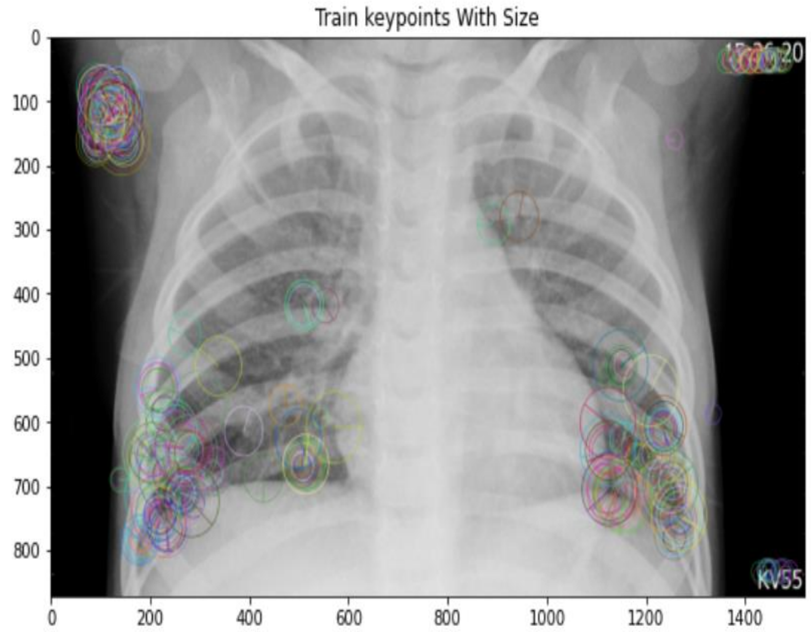


Image input



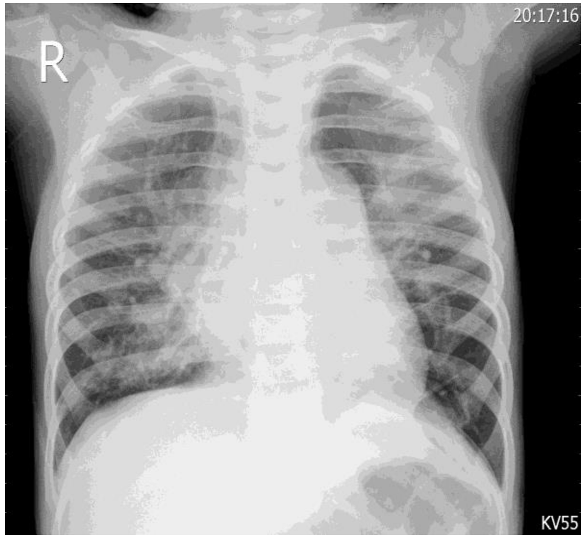
Feature Detection (keypoints detector, descriptors)

What is ORB?

- ORB performs feature detection like SIFT/SURF
- Order of 2x faster than SIFT/SURF
- Fast keypoint detector
- Bried descriptor
- Non-patented

Training Stage

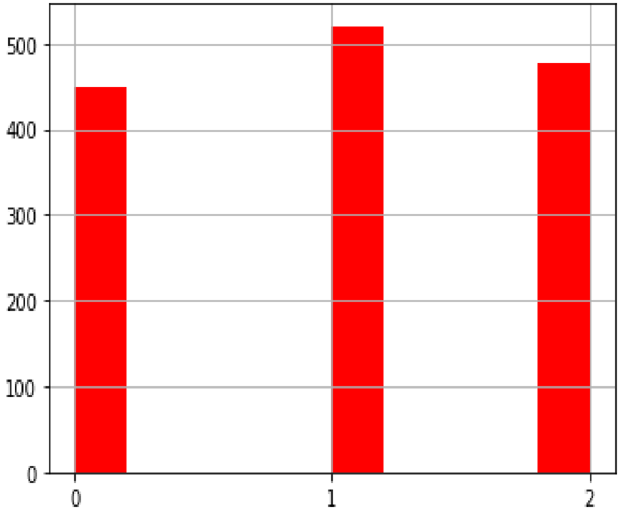
PCA + KMEANS + SVM



Feature Descriptors

Dimension Reduction

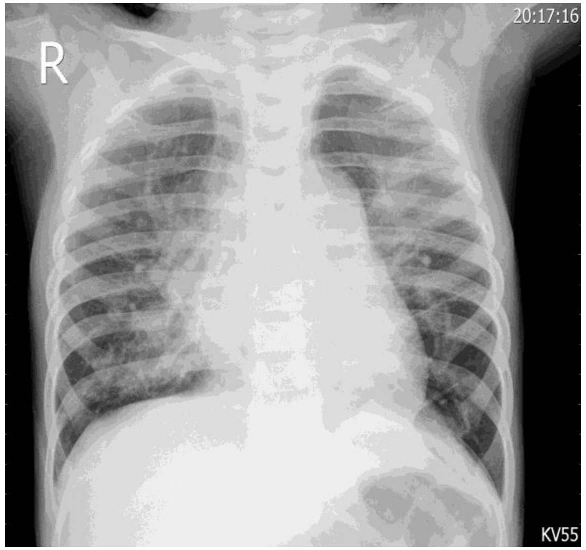
Cluster Labels



Using **class labels** and **feature descriptors** of an image we can train **SVM** to classify the image

Testing Stage

ORB + SVM CLASSIFIER



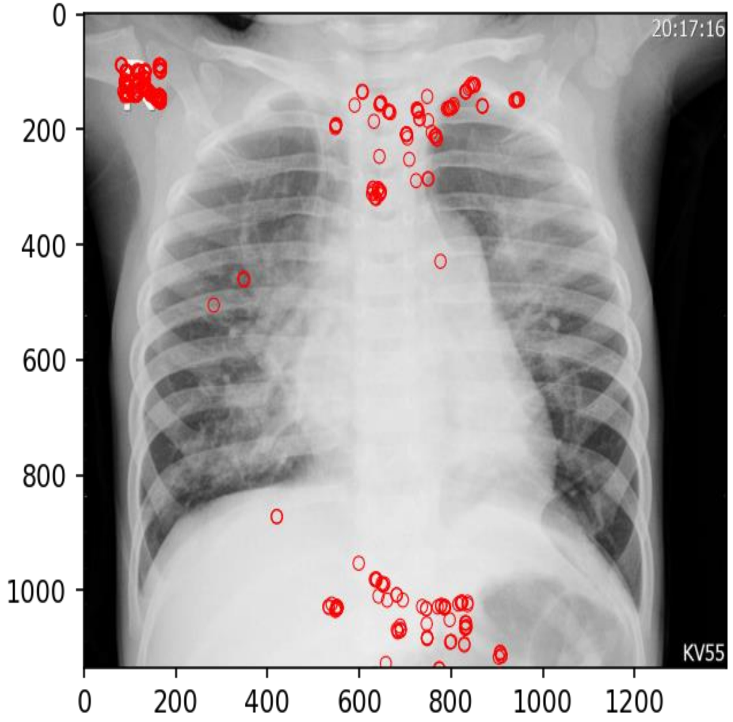
ORB

(Feature Descriptors)

SVM

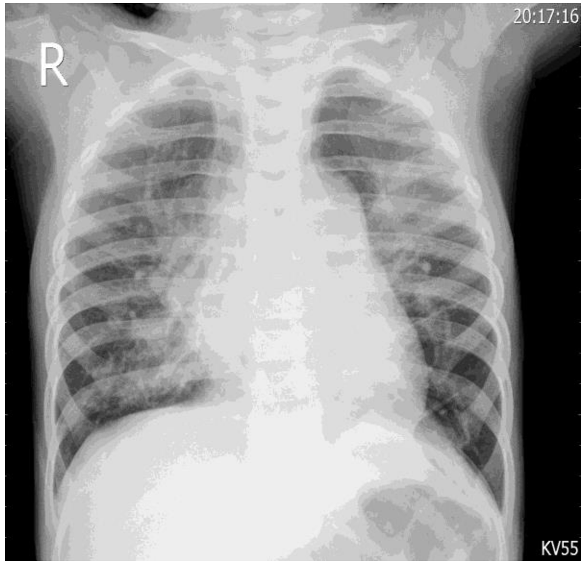
(Normal/ Abnormal)

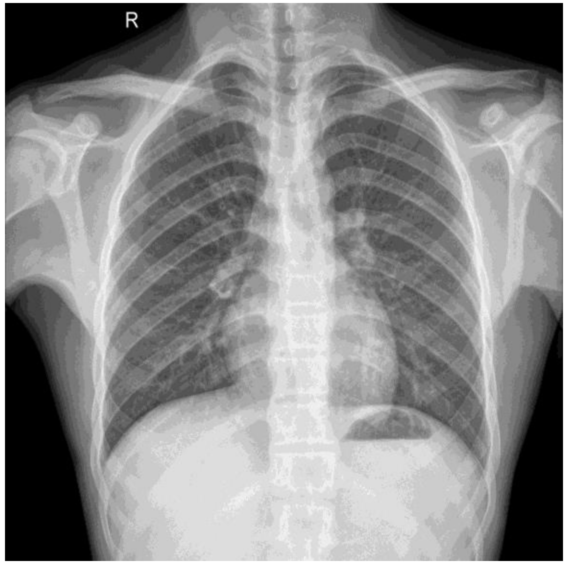
Draw Patches

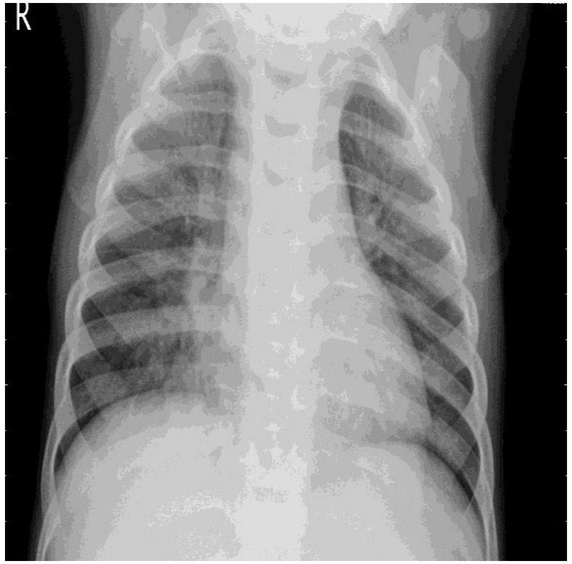


Testing Stage

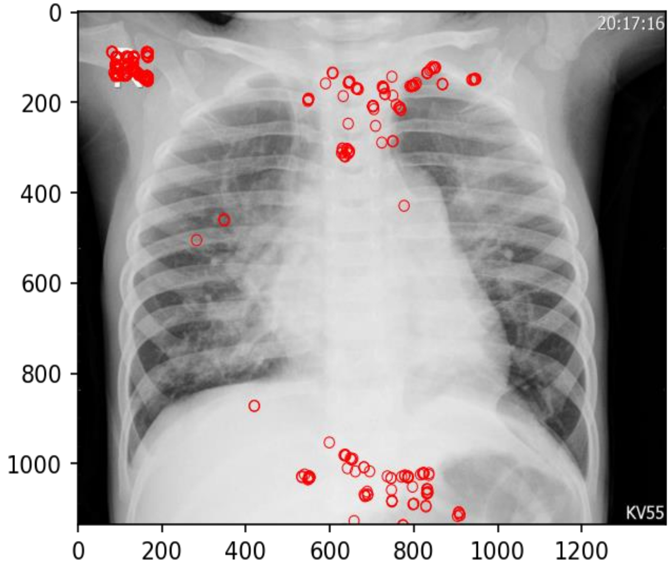
Image Input (Unlabeled)

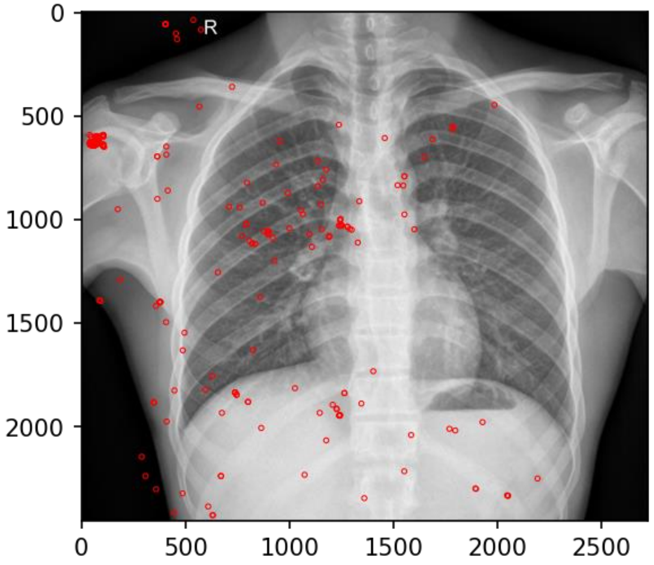


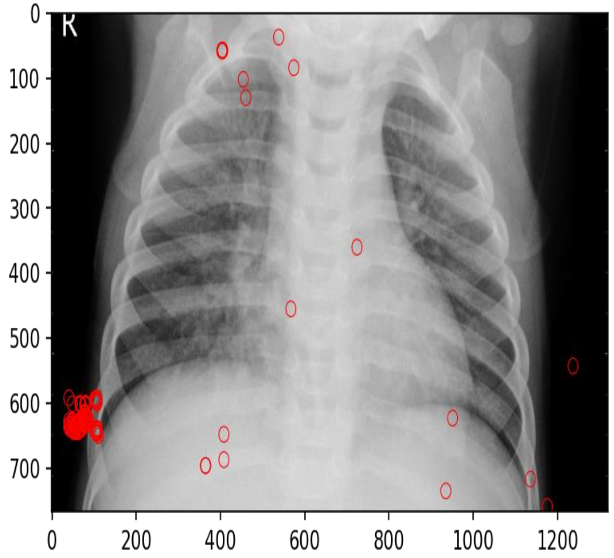




Patches drawn around regions of interest







WEAKLY SUPERVISED FEATURE LOCALIZATION WITH CNN

Technique 2

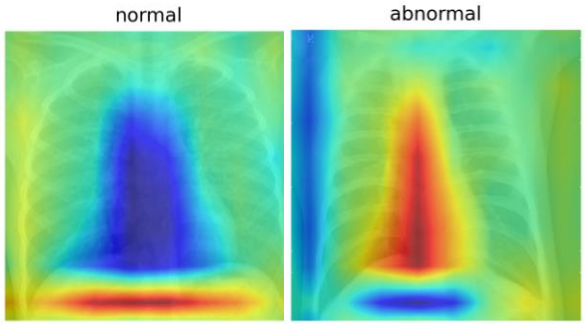
Weakly-supervised feature localization

Weak supervision

Pixel labels

Bounding box generation

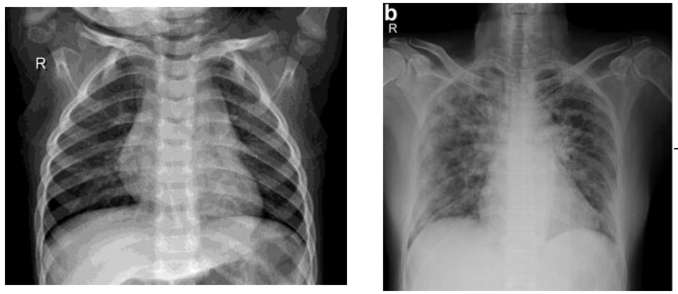
Using only
Bounding box we
can generate
pixel labels



Heat map
Showing how
CNN takes
decisions

Image labels

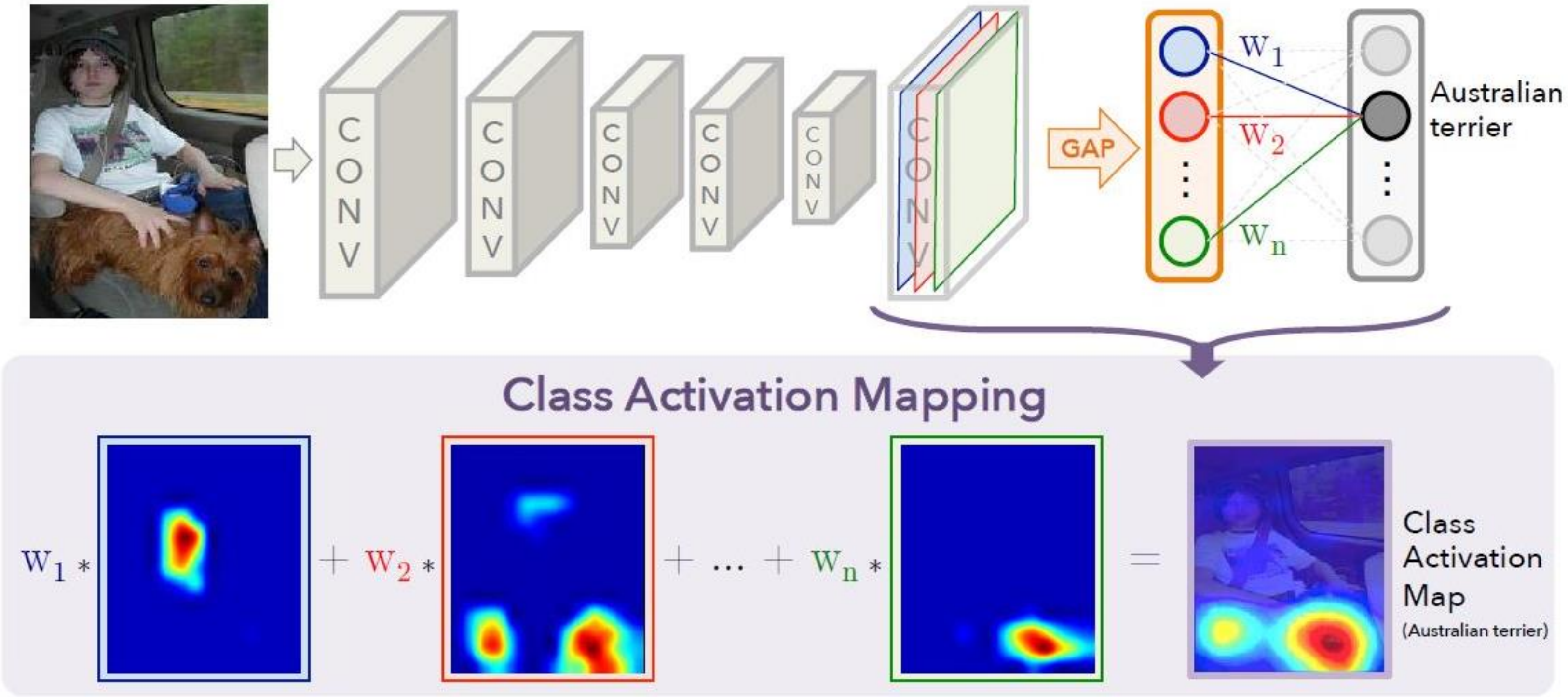
Using only
Class labels of an image
We can generate bounding
box of class labels



Normal Abnormal

Weakly-supervised feature localization

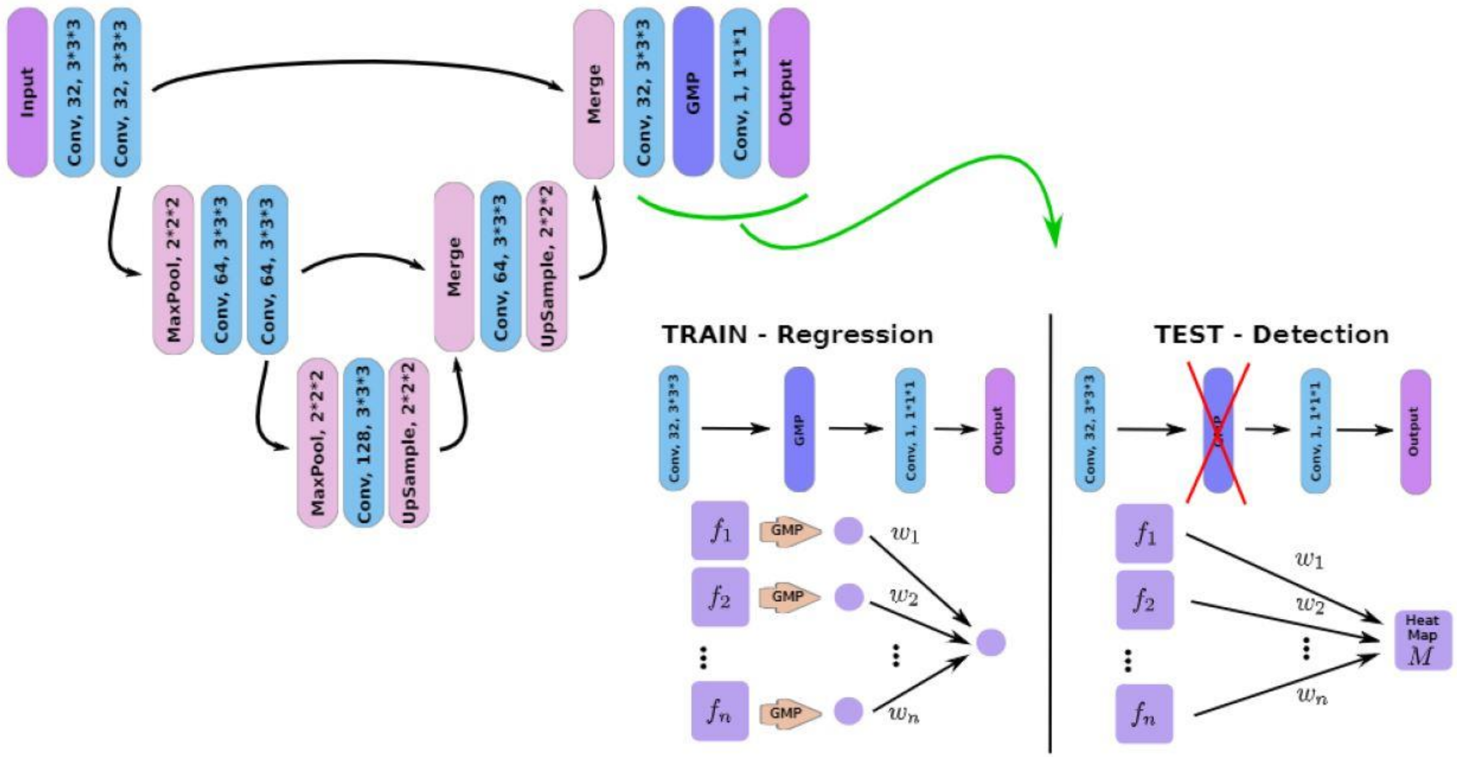
Related works: *Learning Deep Features for Discriminative Localization*



Zhou, B., Khosla, A., Lapedriza, A., Oliva, A., & Torralba, A. (2016). Learning deep features for discriminative localization. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 2921-2929).

Weakly-supervised feature localization

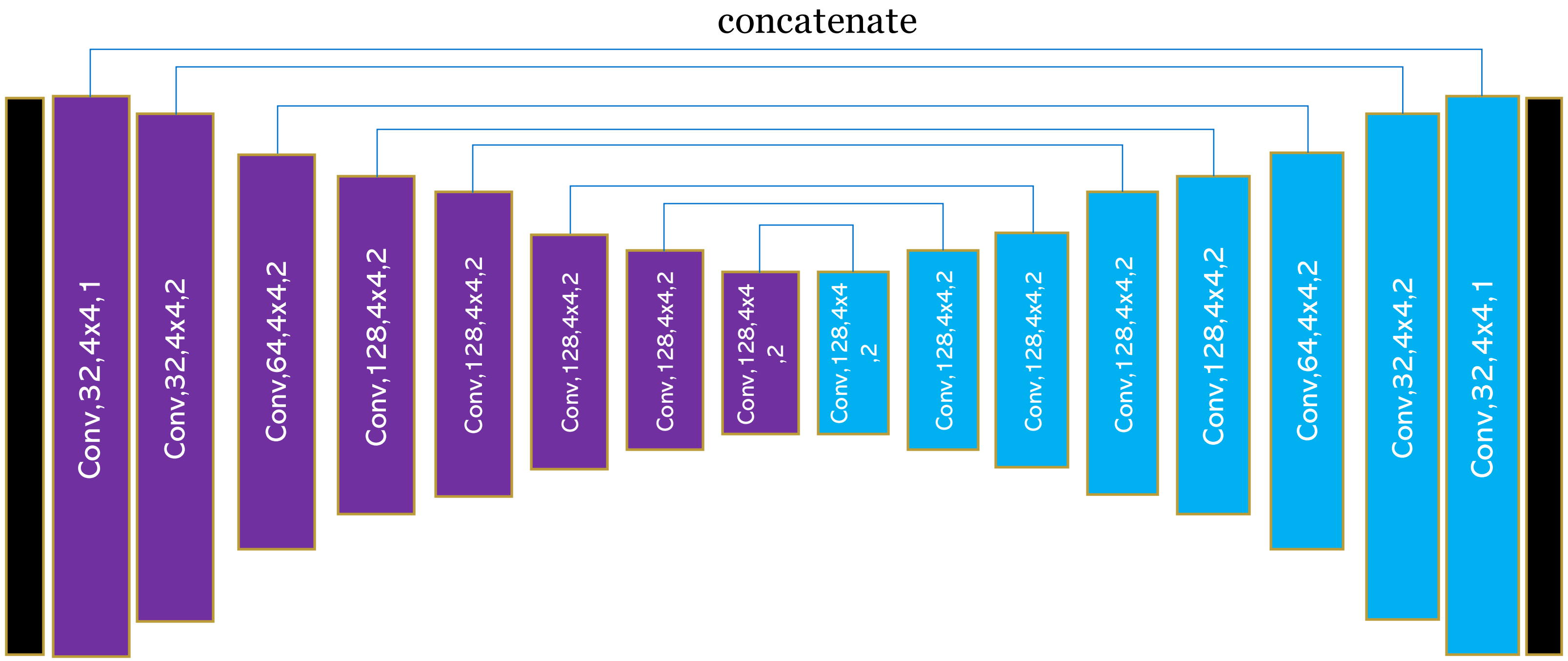
Related works: *GP-UNET: Lesion detection from weak labels with a 3D regression network*



Dubost, F., Bortsova, G., Adams, H., Ikram, A., Niessen, W. J., Vernooij, M., & De Bruijne, M. (2017, September). Gp-unet: Lesion detection from weak labels with a 3d regression network. In *International Conference on Medical Image Computing and Computer-Assisted Intervention* (pp. 214-221). Springer, Cham.

Weakly-supervised feature localization method

Autoencoder architecture



Step 1:

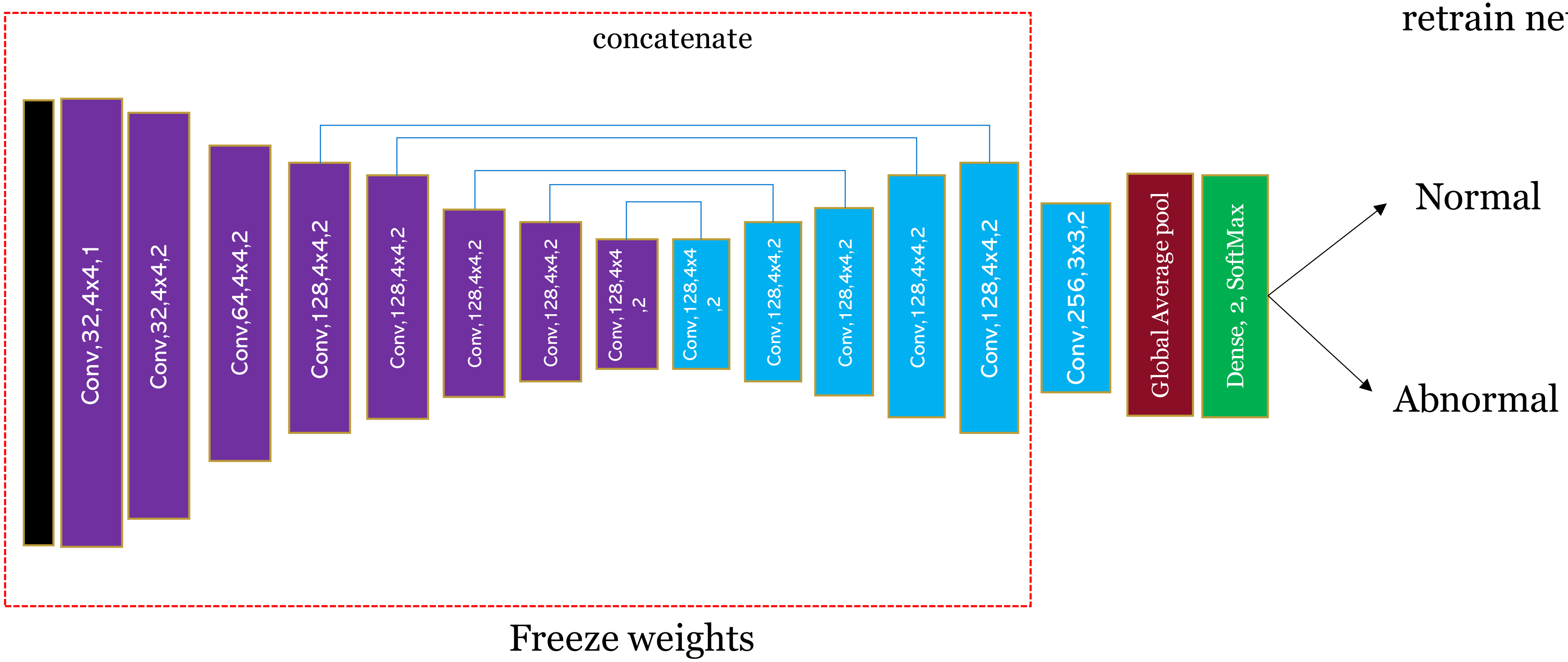
Train an autoencoder network

This was done in order to learn a latent space that captures relevant features on the image.

Weakly-supervised feature localization

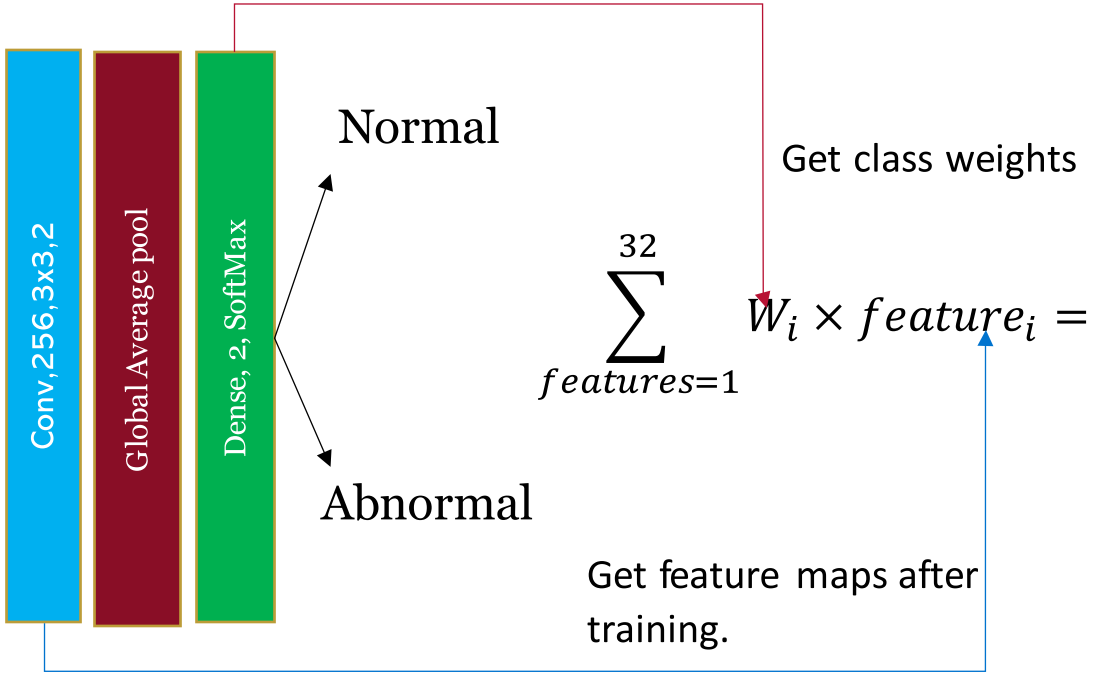
Step 2: Attach Global average pooling and dense classification head and retrain network

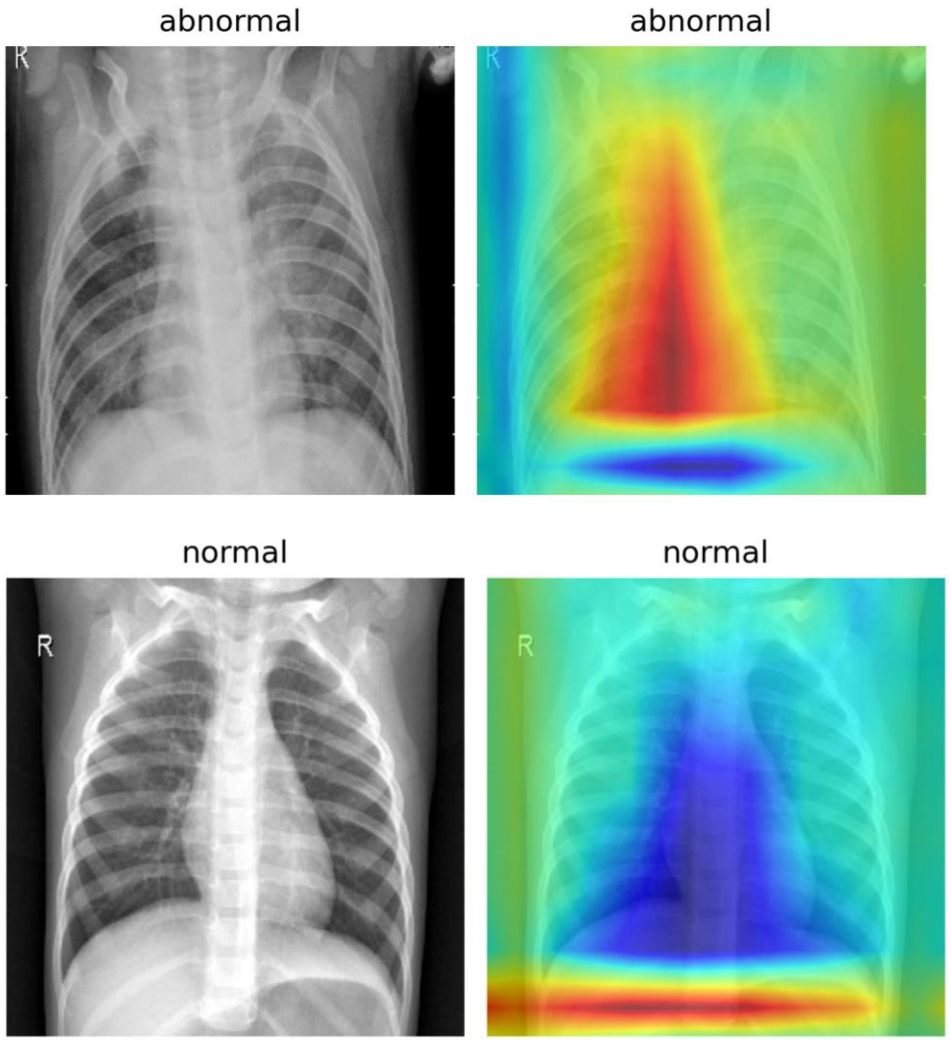
Autoencoder architecture



Weakly-supervised feature localization

Compute feature activations maps

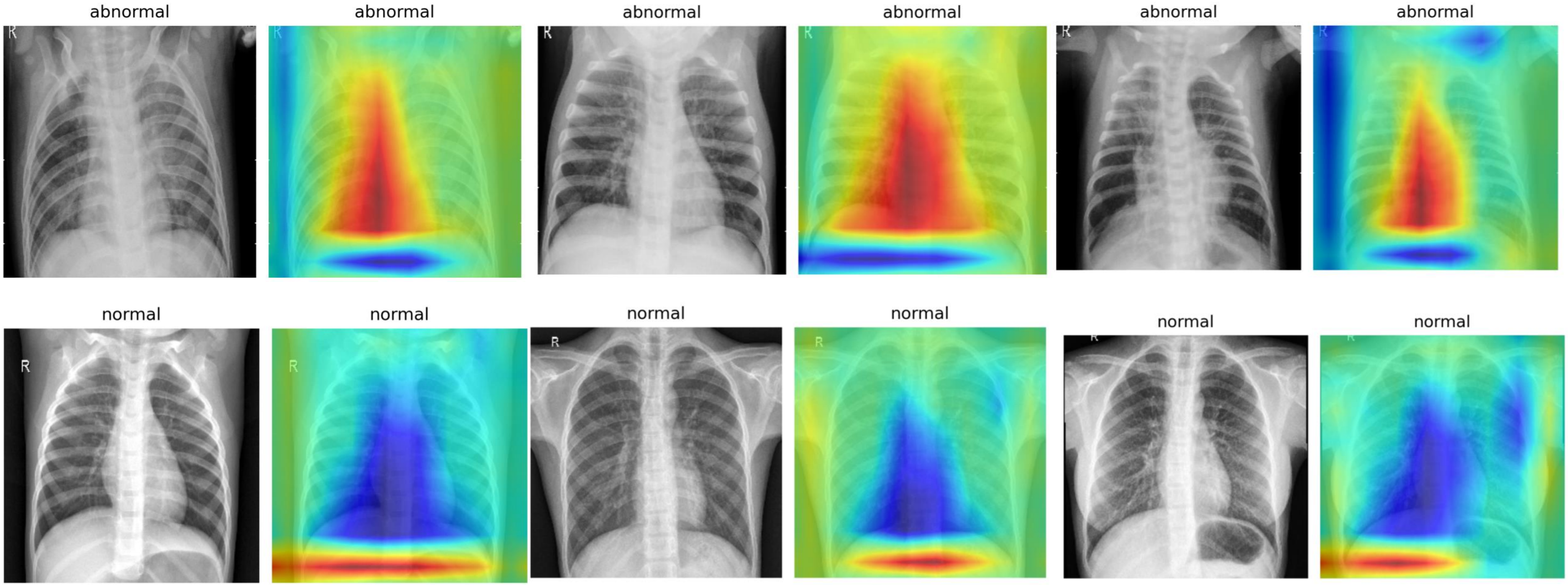




Step 3: We sum the product of the last CNN layer with the weights of the network, apply bilinear resizing

Weakly-supervised feature localization

Results of feature activations maps

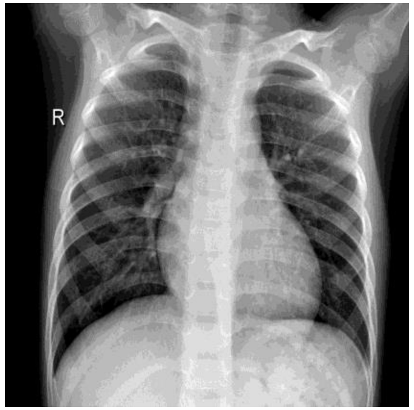


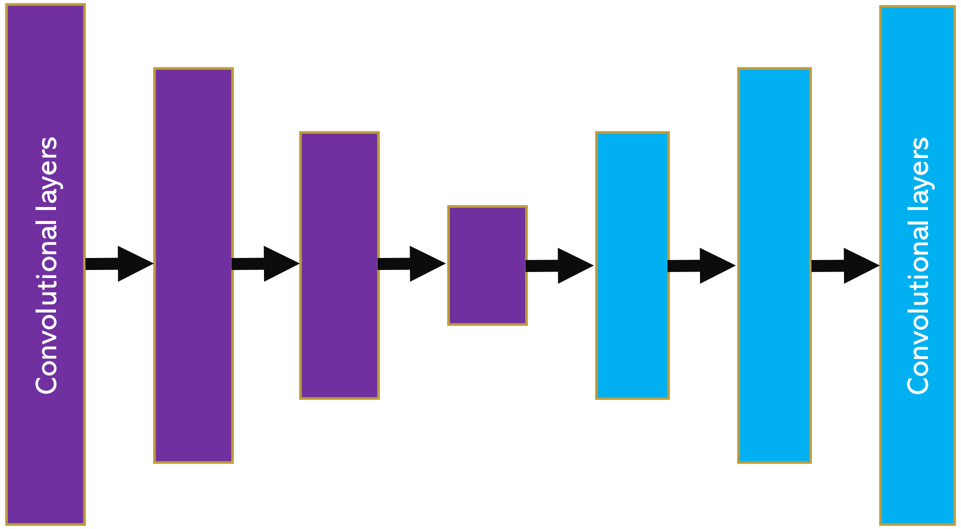
AUTOENCODER CNN

Technique 3

Autoencoder for anomaly detection

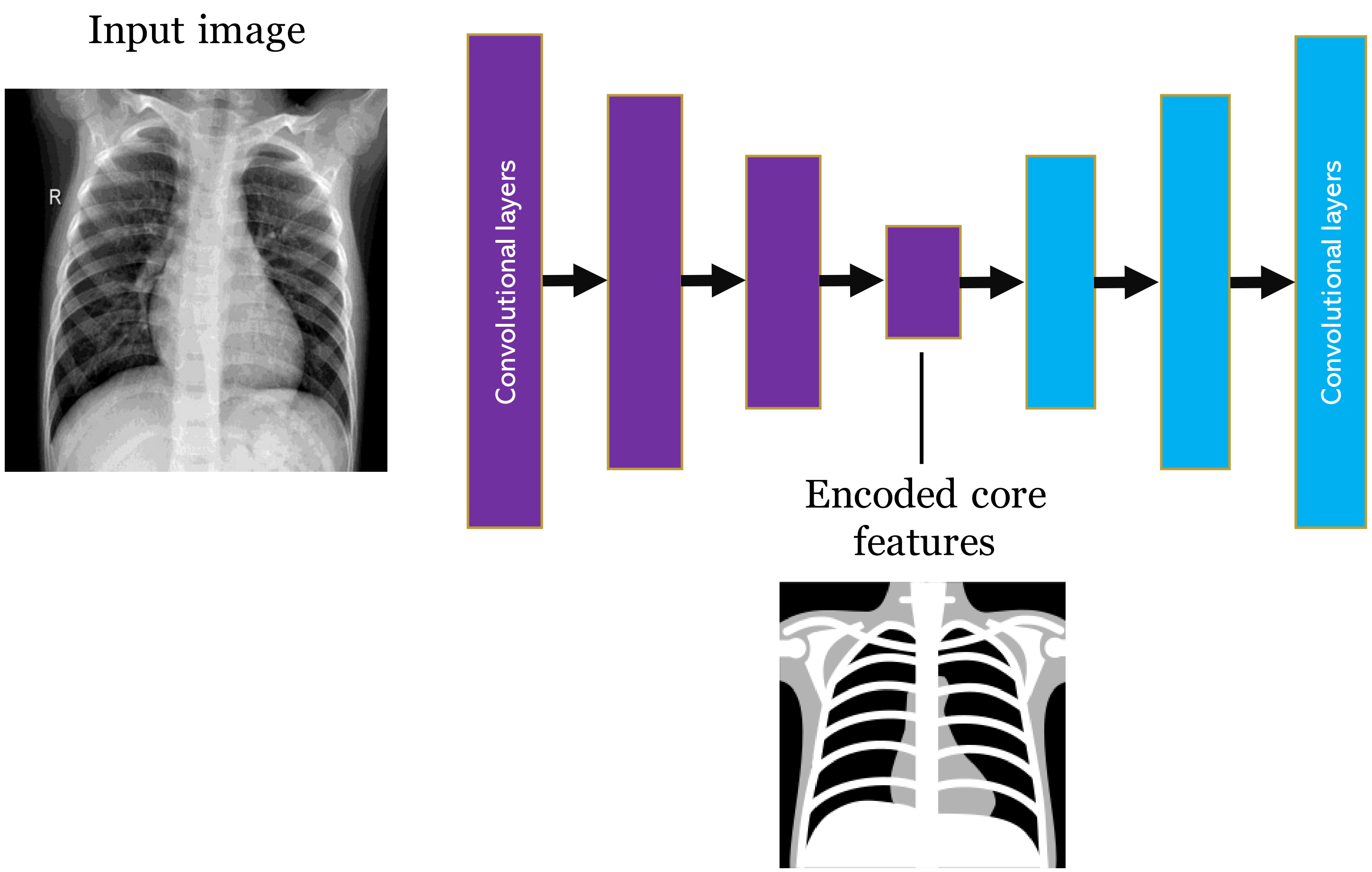
Input image





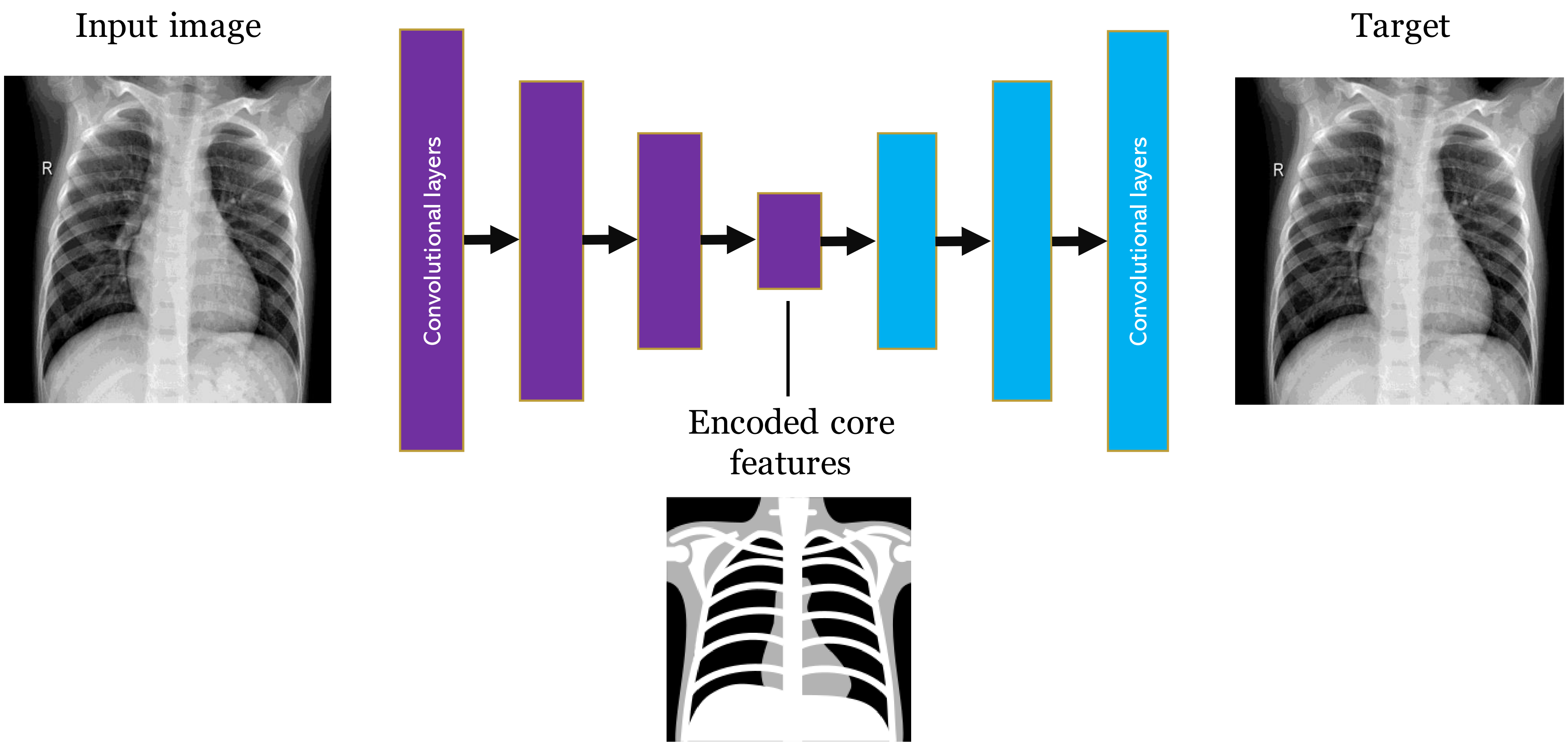
Chest X-Ray image by Jmarchn:
https://commons.wikimedia.org/wiki/File:X-rays_chest_neg_icon.svg

Autoencoder for anomaly detection



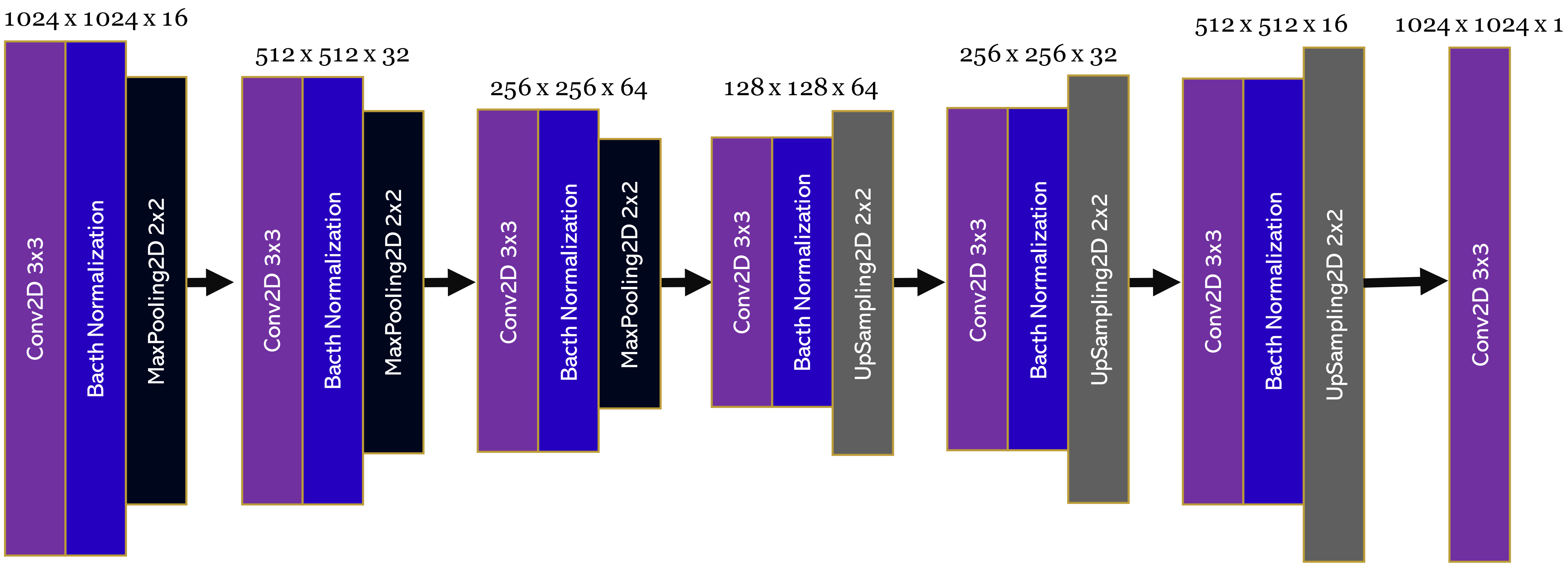
Chest X-Ray image by Jmarchn: https://commons.wikimedia.org/wiki/File:X-rays_chest_neg_icon.svg

Autoencoder for anomaly detection



Chest X-Ray image by Jmarchn:
https://commons.wikimedia.org/wiki/File:X-rays_chest_neg_icon.svg

Version 1: Sequential

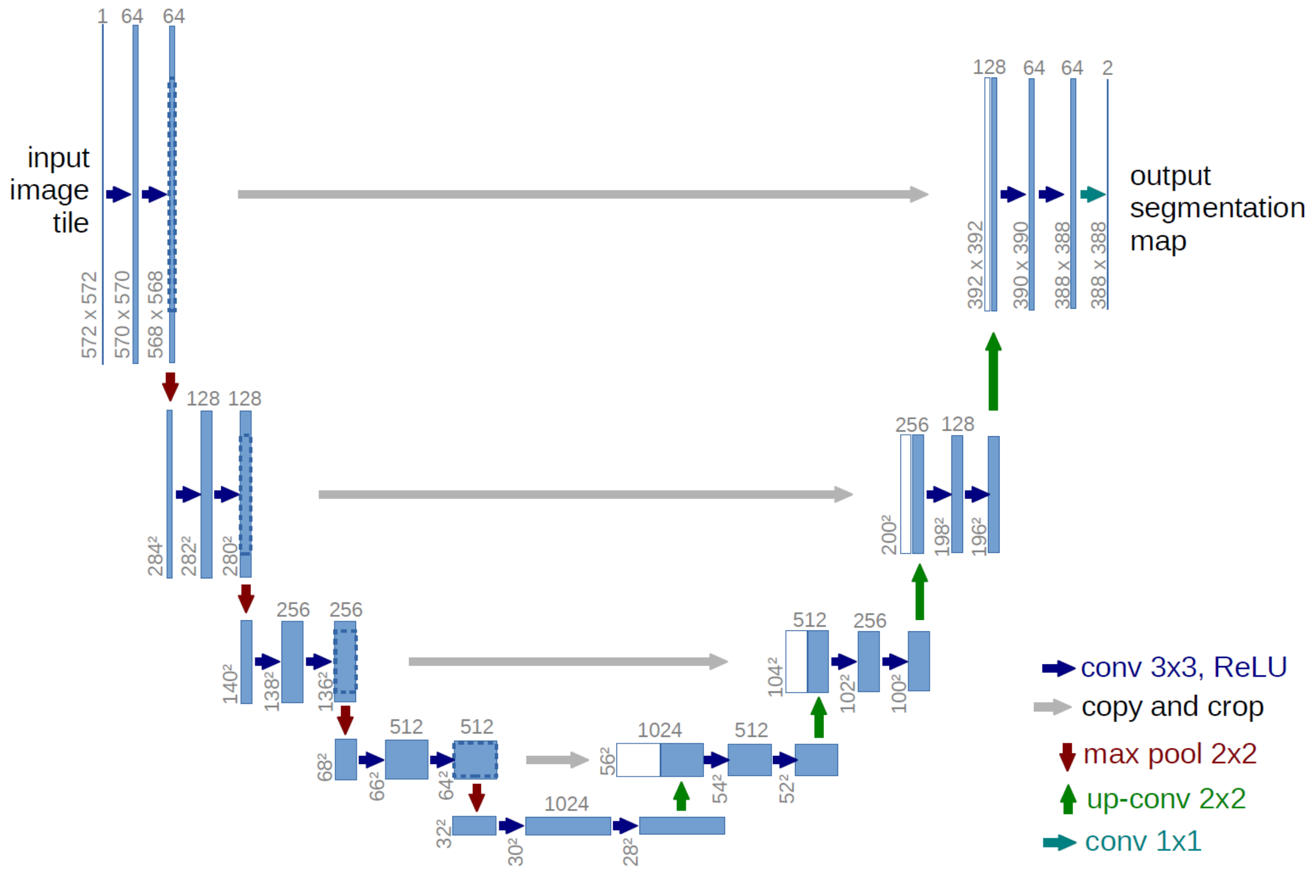


Lyudchik, O., Vlimant, J., & Pierini, M. (2016). Outlier detection using autoencoders.

Version 1: Sequential

Results

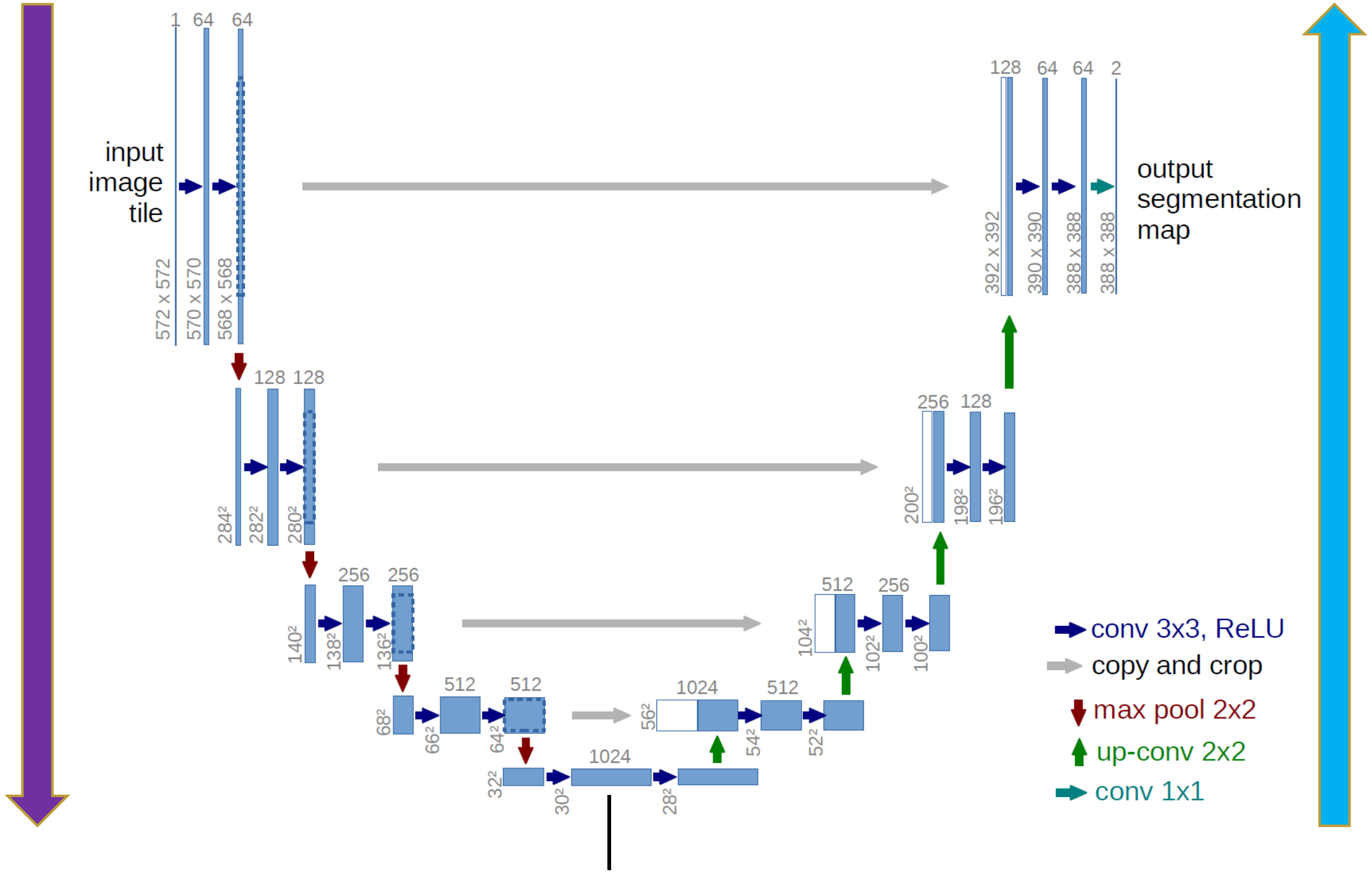
Version 2: U-Net



"The u-net architecture achieves very good performance on very different biomedical segmentation applications."

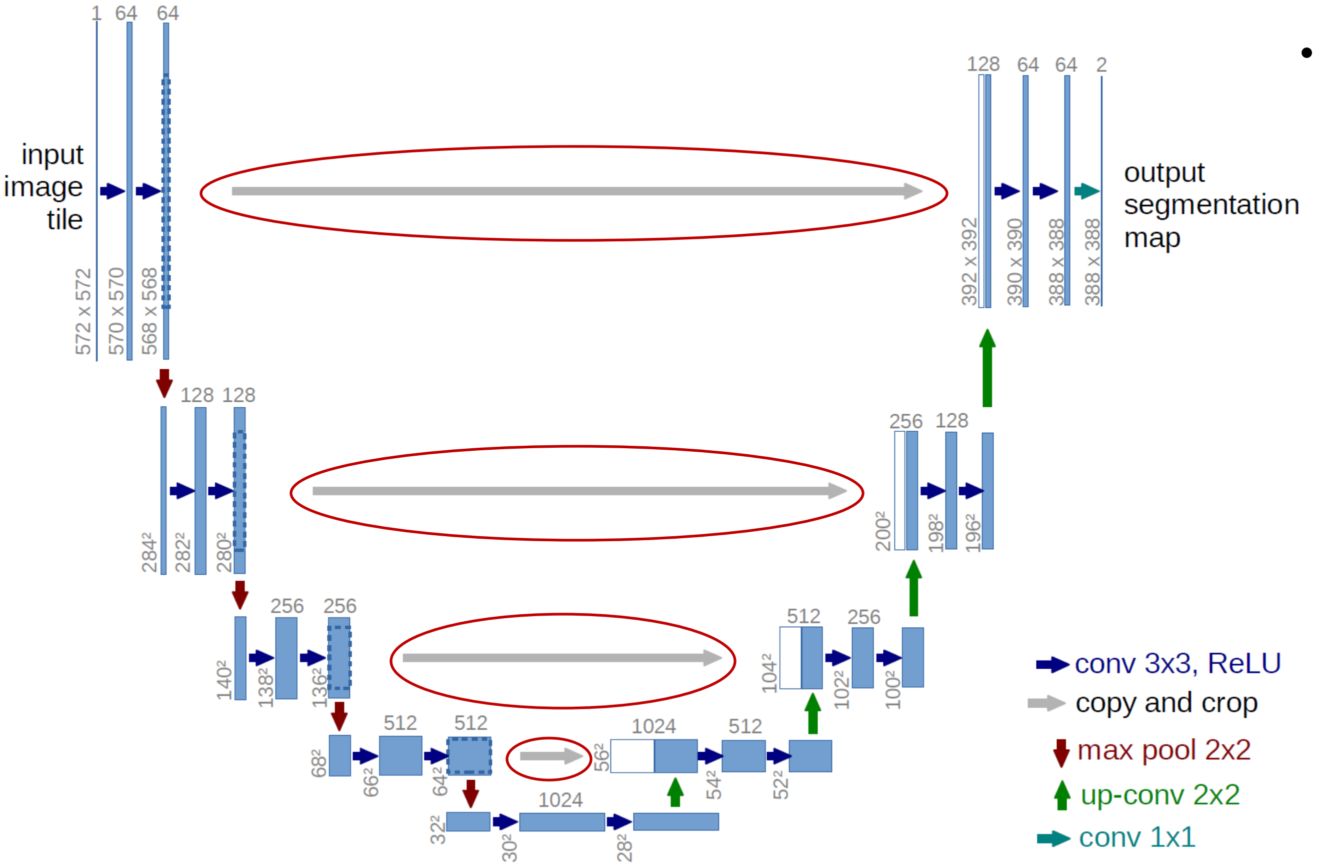
Ronneberger, Olaf & Fischer, Philipp & Brox, Thomas. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. LNCS. 9351. 234-241. 10.1007/978-3-319-24574-4_28.

Version 2: U-Net



Encoded core features

Version 2: U-Net



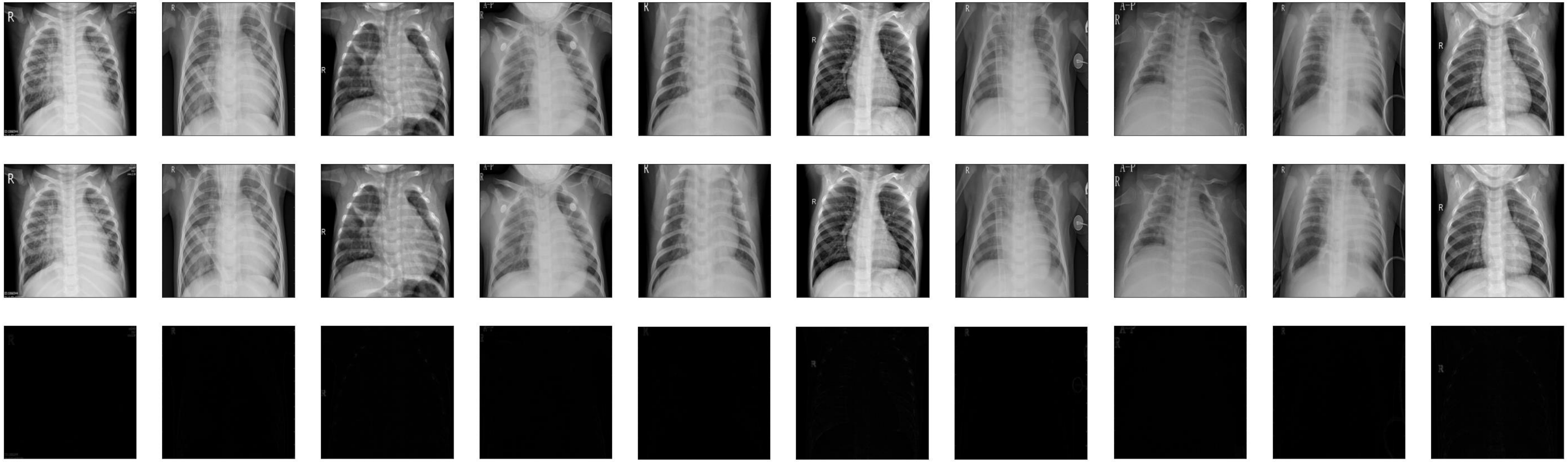
- Adds high resolution features
  - Localize details

Version 2: U-Net

Original

Reconstruction

Difference



Version 2: U-Net