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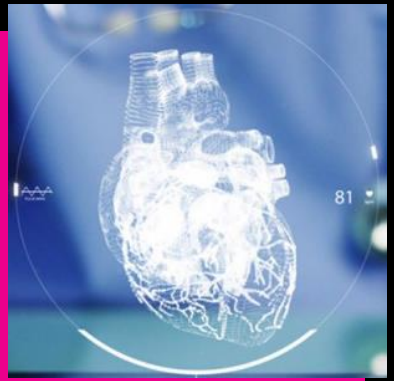

Pericardial Effusion Detection on Post-Mortem Computed Tomography Images Using Convolutional Neural Networks

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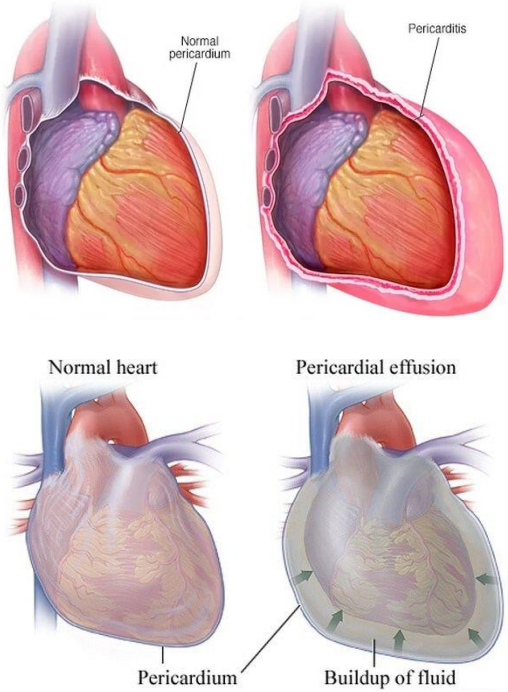
Pericardial Effusion

- Pericardial effusion is the build-up of extra fluid in the space around the heart.
- If too much fluid builds up, it can put pressure on the heart. This can prevent it from pumping normally.
- A number of conditions can cause excess fluid and inflammation in the pericardial sac

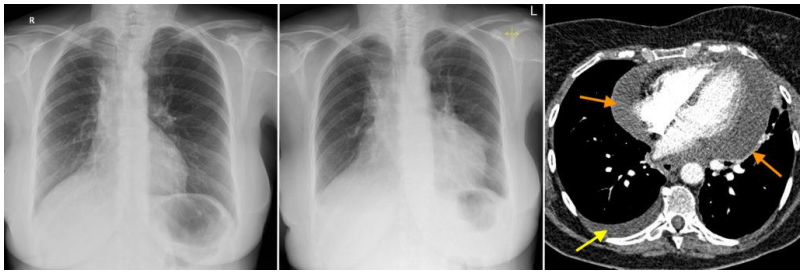
- Cancer
- Infection of pericardial sac
- Inflammation of the pericardial sac
- Injury
- Immune system problems

- Metabolic cause
- Reactions to certain medicines
- Radiation
- Unknown causes



Source: http://nursingexercise.com/pericarditis-disease-causes-treatment/

Pericardial Effusion



Source: http://www.svuhradiology.ie/case-study/pericardial-effusion-cxr-ct/

- Diagnosis of pericardial effusion
  - Medical history and physical exam
  - Chest X-ray to see the heart anatomy
  - Imaging of the chest or heart with a CT scan or MRI
  - Echocardiogram (echo) to look at fluid around the heart and heart motion
  - Electrocardiogram (ECG) to analyse the heart's electrical rhythm
  - Blood test: C-reactive protein (CRP), Blood Urea Nitrogen (BUN), Troponin-I, CK-MB, Myoglobin, ESR
- Many pericardial diseases such as acute pericarditis begin suddenly with cough, pain and/or chest tightness and are difficult to be distinguish from a cardiac arrest.

Challenges

- The traditional diagnosis methods rely on the fluidity of blood.
- In the forensic setting, loss of fluidity of blood causes serious challenges
- Post-mortem computed tomography (**PMCT**) has become an efficient tool to investigate the cause of death by performing a quick whole-body examination to avoid long waiting times and religious conflicts caused by traditional autopsy.
- However, forensic pathologists face challenges in processing a vast number of PMCT images for pericardial effusion detection in practice due to
    - High cost of training qualified forensics
    - Limited human resources and funds

Source: Burke, Parsons & Bassed (2012)

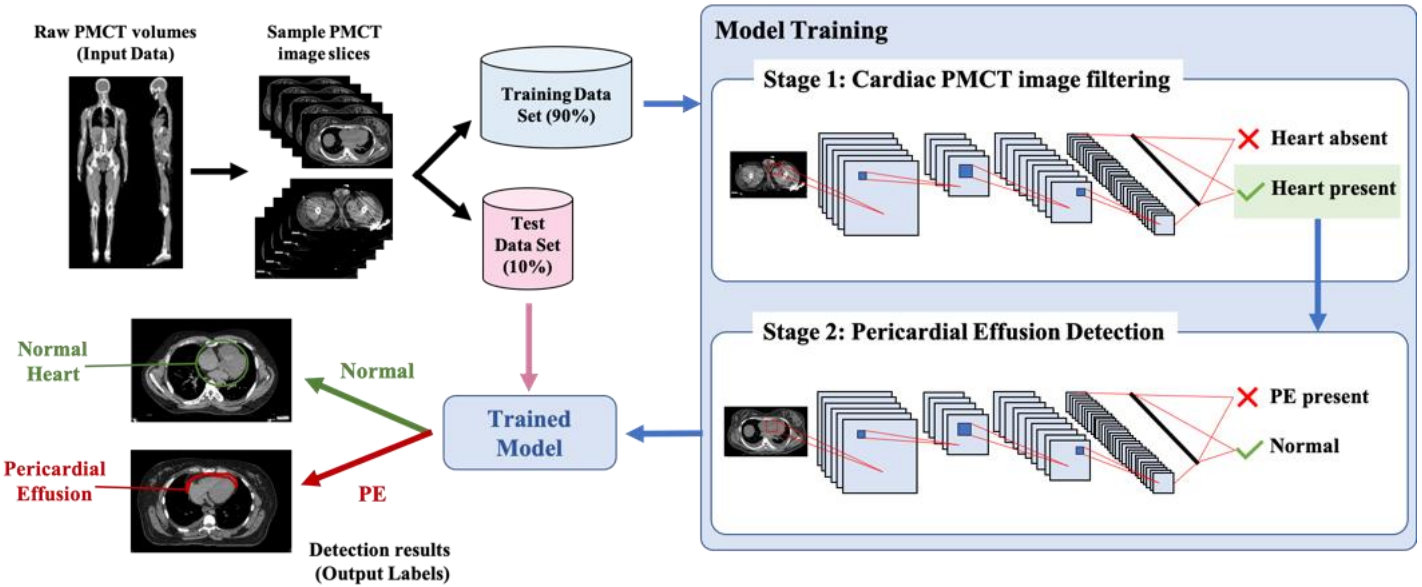
Related Research Work

- In the past two decades, deep learning technologies have achieved good performance in many fields, especially image processing.
  - Assist medical practitioners in decision-making efficiently
- Echocardiogram images were used to build deep learning models to detect pericardial effusion.
- But few works have been done in forensic image processing.
- The detection of pericardial effusion on PMCT image is still open.
  - The algorithm structure is unclear
  - The datasets are in small size
  - Only one slice of PMCT scan is extracted from each case

Our Solution

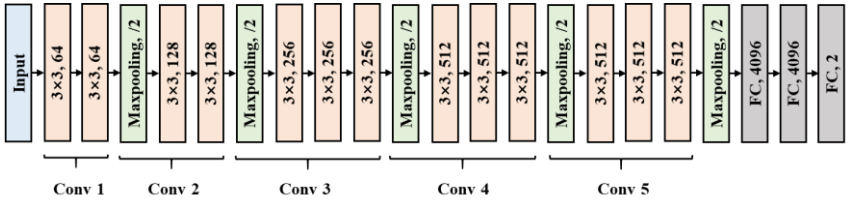
- Our solution is to automatically detect pericardial effusion on PMCT images using deep learning techniques.
- We aim to
  - Introduced a new framework that can detect pericardial effusion automatically using whole-body PMCT images collected from real-world medicolegal cases
  - Design and modify new VGG- and ResNet-based image processing models that fit the specific characteristics of PMCT images; and
  - Find out the relatively better CNN models by evaluating the proposed models' performance against the other popular ones on the collected PMCT images.

Our Solution – PEAD Framework

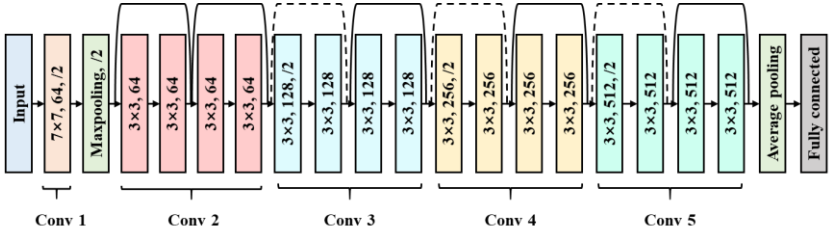


Modified VGG & ResNet Models for PMCT

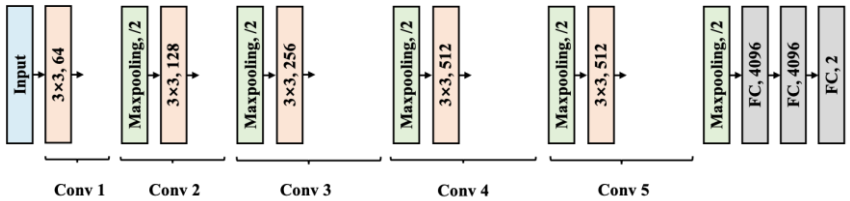
VGG16 model (standard)



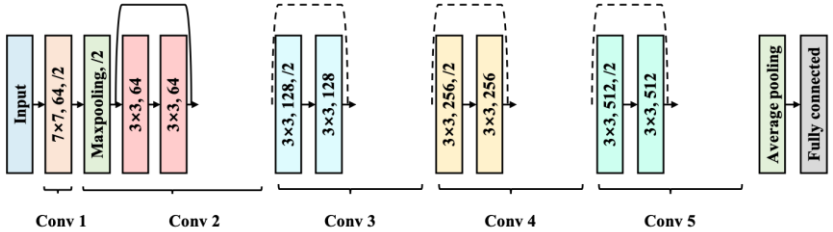
ResNet18 model (standard)



VGG8 model

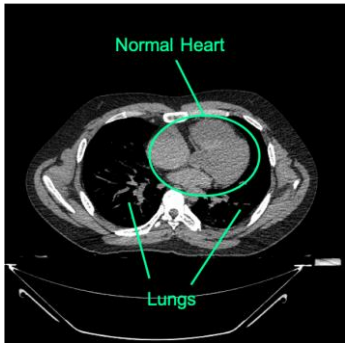


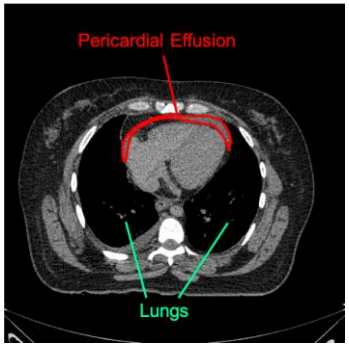
ResNet10 model



Data Sets

- A PMCT DICOM sets for 93 deceased individual cases from the **New Mexico Decedent Image Database** (NMDID) by University of New Mexico from https://nmdid.unm.edu/
- Each case consists of 1,500 PMCT slices
- Not all slide in every case were used
  - 2,437 PMCT slices were extracted from the raw dataset
  - 1,124 heart-present slices and 1,313 heart-absent slices
  - 47 cases with pericardial effusion and 46 cases with no cardiac abnormality
  - 563 slices with pericardial effusion and 561 slices with normal heart tissue
  - 46 males and 47 females





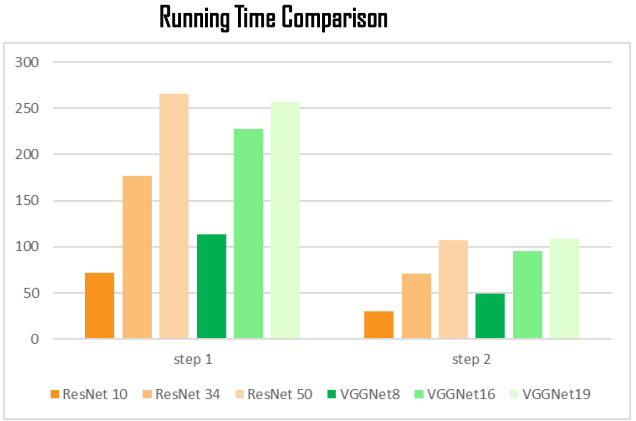
Performance Results

Step 1: PMCT Heat Slices Filtering

Models	Test acc	Precision	Recall
VGG8	**96.33%**	**94.90%**	**98.50%**
VGG16	95.44%	94.47%	97.35%
VGG19	95.58%	93.94%	97.92%
ResNet10	**96.01%**	**94.04%**	**98.81%**
ResNet34	95.44%	93.38%	98.48%
ResNet50	94.45%	92.55%	97.50%

Step 2: Pericardial Effusion Detection

Models	Test acc	Precision	Recall
VGG8	**91.16%**	**94.09%**	**88.37%**
VGG16	84.82%	85.25%	84.34%
VGG19	84.29%	87.50%	81.51%
ResNet10	**88.39%**	**89.98%**	**86.45%**
ResNet34	84.73%	85.82%	83.21%
ResNet50	81.88%	82.51%	80.89%



Summary of Findings

- The proposed PEAD framework can provide technical support for forensic pathologists in processing and analysing large amounts of PMCT data quickly to assist in death investigation.
- Deep learning techniques can help save time and improve efficiency in detection of pericardial effusion from whole-body PMCT images automatically.
- Simplified VGG8 and ResNet10 models can obtain acceptable performance to quickly filter out irrelevant images and detect pericardial effusion efficiently.
- VGG8 can provide the best accuracy.
- ResNet10 can achieve a close performance but much faster.

Thank You!
Any Question?