# Detection and Severity Classification of Aortic Stenosis with Automated Deep Learning Transformers

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**Background:**
Aortic stenosis (AS) is characterized by calcification and restricted opening of the aortic valve and is the deadliest valvular cardiac disease. Assessment of AS severity is typically done by expert echocardiographers using 2D echo and Doppler measurements of valvular flow from echocardiography. However, this limits the assessment of AS to hospitals staffed with experts to provide comprehensive echocardiography service. In this work, we present a novel deep learning framework to determine the feasibility of a transformer-based model for AS detection and severity classification based only on two-dimensional echocardiographic data.

**Methods:**
A dataset of PLAX and PSAX echo cine series was obtained from a tertiary care university hospital. The dataset included 2247 patients and 9117 echo cine series. Only patients with an agreement between three Doppler markers related to AS (AV area, peak valvular jet velocity, and mean pressure gradient) were selected. The dataset was anonymized and cines containing colour or spectral Doppler were removed. A transformer-based model was trained with 70% of existing samples with an equal ratio of normal, mild, moderate, and severe grade of AS. The accuracy of the model was evaluated from a test set containing 10% of samples that were not included during training.

**Results:**
Our architecture outperforms the state-of-the-art results, achieving 95% in AS detection, and 78% in AS severity classification. Our proposed spatio-temporal architecture effectively and efficiently combines both anatomical features and motion of the aortic valve for AS severity classification. Our model can process cardiac echo cine series of varying length and can identify the frames that are most informative towards the AS diagnosis while learning phases of the heart cycle without any supervision and frame-level annotations.

**Conclusion:**
In this work, we introduce a novel transformer-based architecture for accurately automating the assessment of aortic stenosis severity in cardiac echo cine series. Further studies are being conducted to include interpretability as part of our design and to facilitate the adoption of the approach in real life settings.

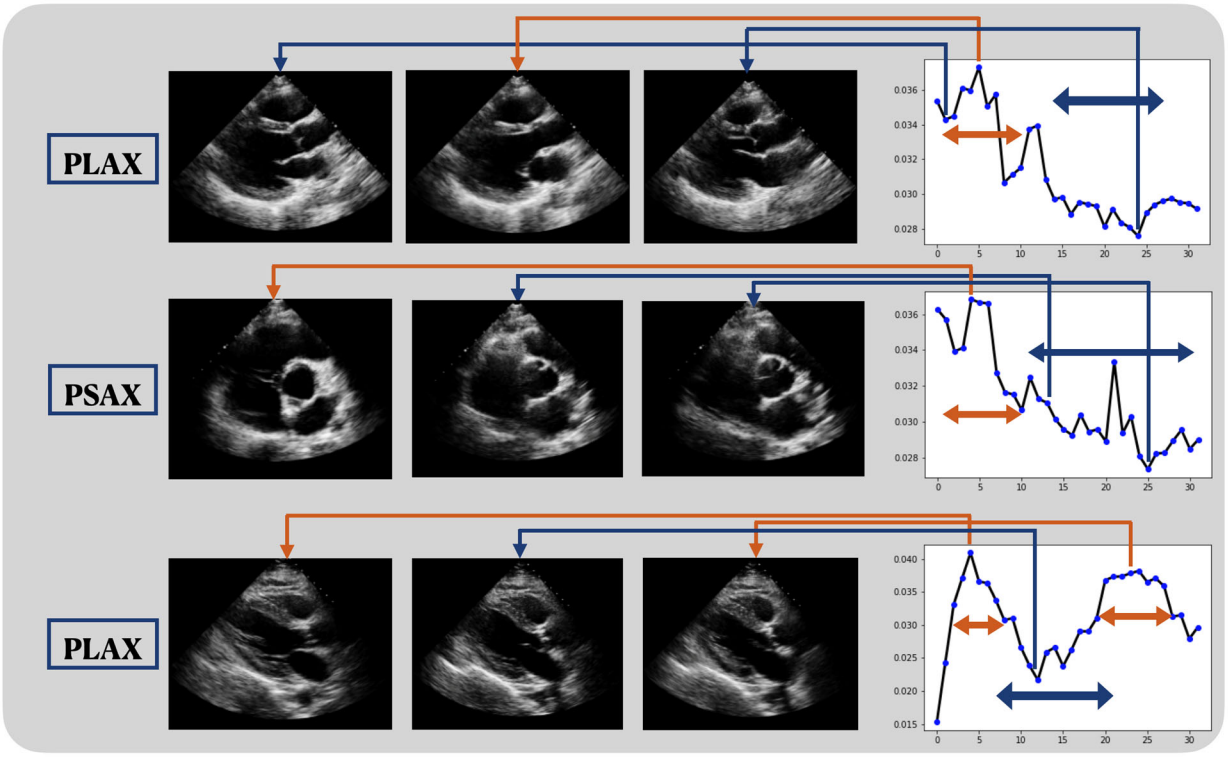


**Figure 1.** This study provides qualitative instances of the deep learning framework's capability in learning the informativeness of frames. The diagram on the right shows the attention weights associated with frames of each video. Three sample frames of each video are shown on the left side. The orange arrows show the interval of frames with an open AV and its associated attention weights. Blue arrows represent the closed AV both before and after heart's contraction.

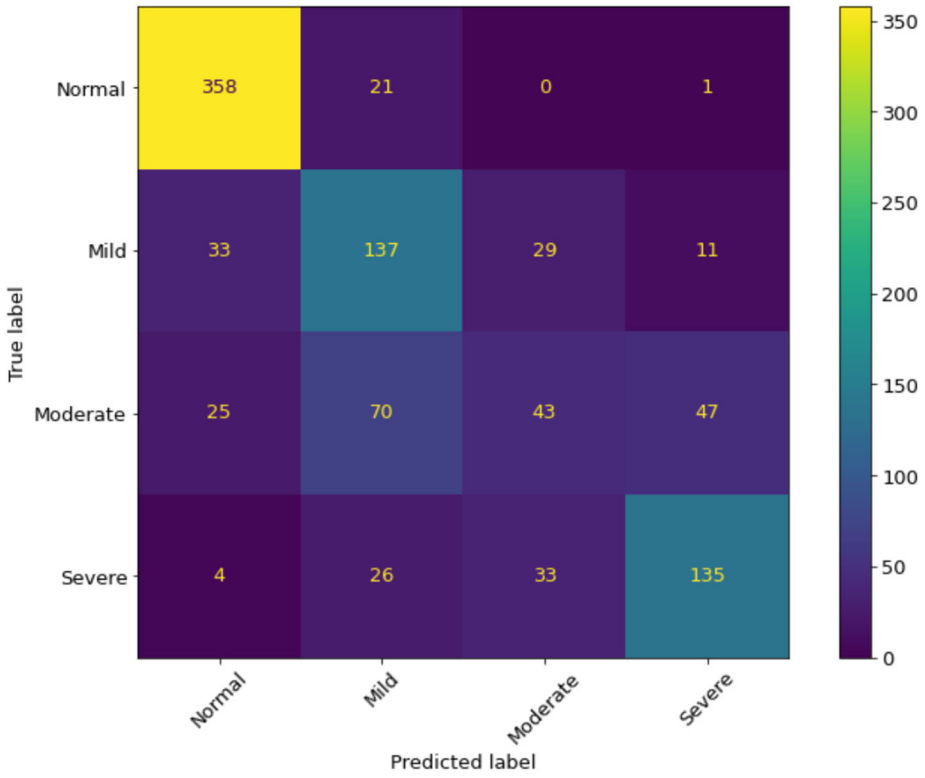


**Figure 2.** Confusion matrix for AS severity assessment. Rows represent predicted values (Normal, Mild, Moderate, Severe) and columns represent ground truth values.

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