Improving Structural Analysis Duration Using Machine Learning Methods

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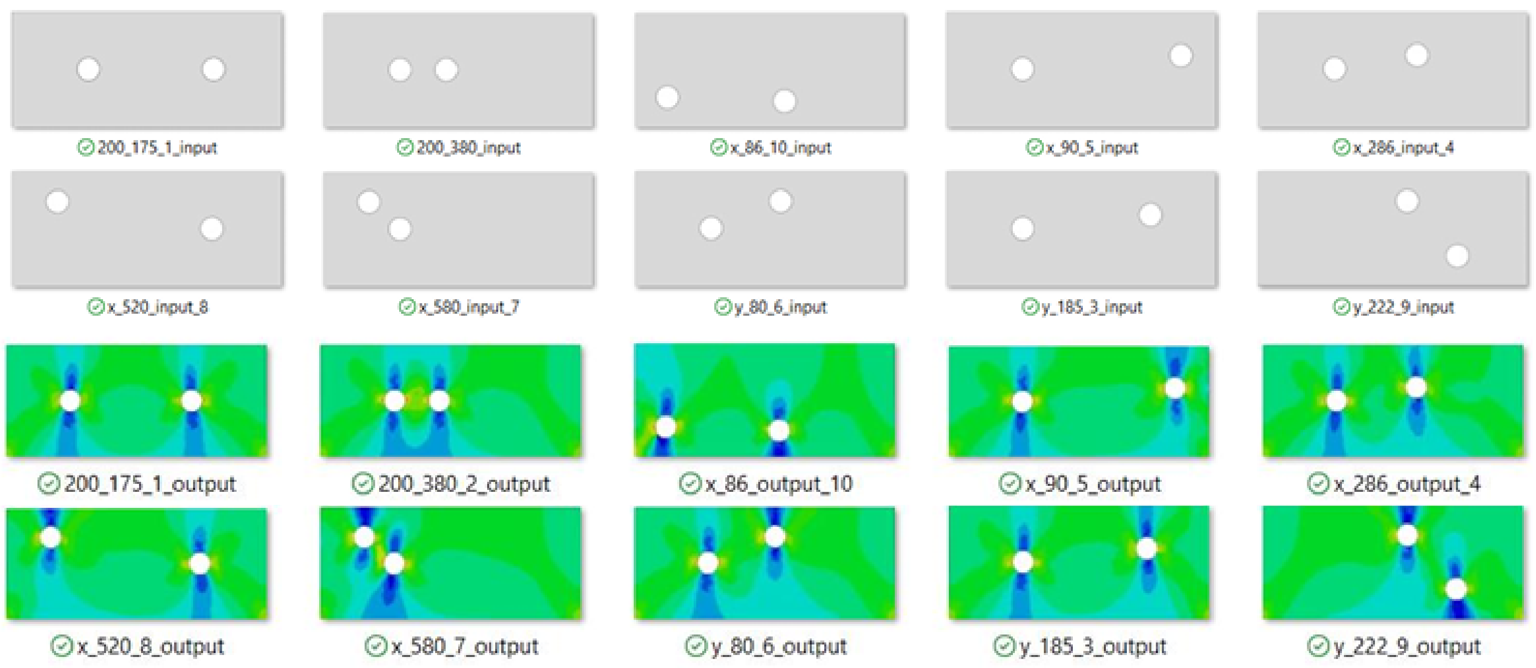
This study was carried out with the support of **Turkish Aerospace Industry (TAI)** and aims to reduce the duration of structural analysis processes and accelerate the engineering design cycle. Traditional structural analysis methods, especially for complex geometries and loading conditions, require high computational cost and long processing time. To address this issue, a machine learning-based model was developed that learns from previous analysis data. The proposed model can predict new analysis scenarios with high accuracy and low computation time, thus providing significant efficiency in terms of both time and resources in engineering applications.

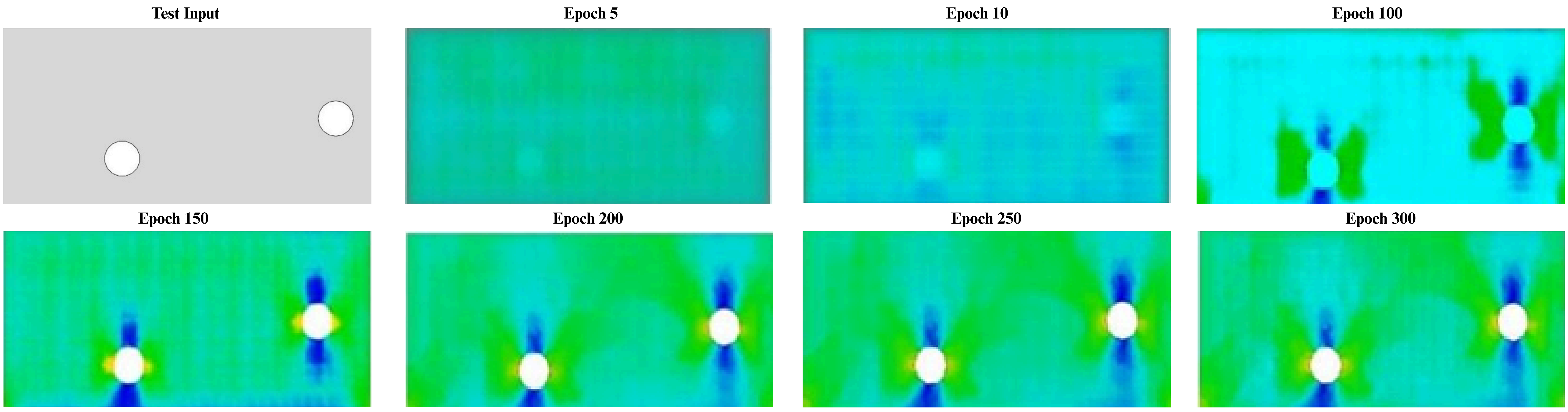
Input and Output Data



Method

A machine learning-based Conditional Generative Adversarial Network model was developed to quickly and accurately predict the stress distribution of two-dimensional (2D) plates. The model uses geometric features and boundary conditions as inputs, and stress distribution maps as outputs. It consists of a U-Net generator and a PatchGAN discriminator. The model was trained on 10 input-output data pairs representing different structural scenarios and tested on one unseen input to evaluate its performance. Accuracy was measured with SSIM, PSNR, and LPIPS metrics. Results show that the model significantly reduces computation time while maintaining high accuracy, offering an efficient alternative to traditional methods. Training time varies depending on the GPU type; on a T4 GPU, the model was trained in approximately 10 minutes and generated results for individual inputs in 2–3 seconds.

Results and Evaluation



The model was trained for 500 epochs with a batch size of 4. Output images generated at the end of each epoch were recorded and evaluated using performance metrics. Throughout the training process, the model's predictive capability was systematically monitored based on visual similarity-based performance metrics. Upon comparison, the output generated at the 300th epoch was found to provide the best results in terms of overall accuracy and visual quality. Therefore, the 300th epoch was selected as the most appropriate stage for final output generation.

Performance Analysis