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Evaluation of Deep Learning Model for Scoliosis Pre-Screening Using preprocessed Chest X-ray Images

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Introduction

- Scoliosis
  - 3-Dimensional deformation of the spine
    - Physical or disease-related cause
    - The spine is rotated abnormally
    - Classification: Idiopathic(m/c) / Congenital / Neuromuscular
  - Adolescent idiopathic scoliosis(AIS)
    - Early detection has a significant impact on its treatment
    - Usually, manual measurement of the Cobb's angle is used

Introduction

- Chest X-ray Images for Diagnosis of AIS
  - High risk of severe errors and misdiagnosis
  - Insufficient reliability of the diagnosis to determine presence or absence

- Purpose
  - To incorporate the machine learning technology into the diagnostic process
  - To train a deep learning model to detect scoliosis using chest X-ray images alone instead of the full-length spine images

Materials and Methods

- Image Generation
  - 111 Chest X-ray images(dimensions: 224 × 224)
  - Presence or absence of scoliosis had been identified by OS surgeon
  - Original, preprocessed, and generated images
    - Preprocess: Gaussian sharpening, smoothing
    - Generate: for big data to prevent overfitting

Table 1. Number of images used for deep learning

Image type	Spine condition	Training images	Test images
Original image	Normal	49	15
	Scoliosis	33	14
Preprocessed image	Normal	49	15
	Scoliosis	33	14
Generated image	Normal	1,029	315
	Scoliosis	693	294

Materials and Methods

- Deep Learning Model
  - VGG16
    - Type of VGG model with 16 layers
    - Enabling the learning of a deeper neural network
    - 13 convolution layer + 3 fully connected layer
  - ResNet152
    - Have deeper neural network structure by adopting novel method
    - Max 152 layers
  - EfficientNet B0
    - To obtain an optimal performance to adjust depth, width, and resolution of the model to improve accuracy
    - Compound scaling

Materials and Methods

- Training Method
  - Deep learning model was trained on the GTX2080, tensorflow 2.3.1, and Keras 2.4.3 environments
  - Type 1: Checking the classification accuracy for the original images after training the model with the original image data set
  - Type 2: Checking the classification accuracy for the preprocessed images after training the model with the preprocessed image data set
  - Type 3: Checking the classification accuracy only for the preprocessed images after training the model with the additional images generated in addition to the preprocessed image data set
  - Type 4: Checking the classification accuracy for the preprocessed images as well as the generated images after training the model with the additional images generated and with the preprocessed image data set as for Type 3

Results

Table 2. Training results for the Type 1 method

Model	Accuracy	Standard deviation	*p*-value
VGG16	51.7%	±0.001	<.05
ResNet152	59.8%	±0.129	>.05
EfficientNet B0	55.8%	±0.169	>.05

Table 3. Training results for the Type 2 method

Model	Accuracy	Standard deviation	*p*-value
VGG16	51.7%	±0.001	<.05
ResNet152	63.5%	±0.096	>.05
EfficientNet B0	68.7%	±0.074	<.05

Table 4. Training results for the Type 3 method

Model	Accuracy	Standard deviation	*p*-value
VGG16	51.7%	±0.001	<.05
ResNet152	49.6%	±0.018	<.05
EfficientNet B0	51.1%	±0.042	<.05

Table 5. Training results for the type 4 method

Model	Accuracy	Standard deviation	*p*-value
VGG16	51.7%	±0.001	<.05
ResNet152	93.6%	±0.057	<.05
EfficientNet B0	71.7%	±0.033	<.05

Results

- Type 1
  - VGG16 model showed an accuracy of 51.7%,
  - ResNet152 gave an accuracy of 59.8%
  - EfficientNet B0 showed an average accuracy of 55.8%
    - Exhibited the highest performance
- Type 2
  - The accuracy was slightly improved compared to the Type 1 method when image preprocessing was performed
  - Training was not performed properly
    - All images being classified as normal
- Type 3
  - The accuracy was reduced compared to that of the Type 2 method
    - Indicated the importance of the learning results obtained for the preprocessed image
    - D/T the extreme data differences between the training and validation data sets
- Type 4
  - Showed the highest accuracy of all training cases
  - Large increase in the accuracy was observed for the ResNet152 model

Discussion

- Training the CNN Models
  - Data augmentation
    - Insufficient training data capacity may cause issues related to overfitting in the training of the deep learning model
    - The classification accuracy of chest X-ray images obtained from patients can be improved by extracting features through image preprocessing
- Deep Learning Model Training Method
  - Accuracy was expected to be improved by training with the preprocessed image
    - Learning efficiency could be increased through image preprocessing
    - Increase in the size of the data will lead to more accurate results
- Limitation
  - Chest X-ray images used in this study were taken from the front
  - Only the curvature which is identifiable in a 2D image, could be detected
    - Any abnormal rotation occurring from the side to the front or back will not be detectable
- Dx. For AIS
  - Potential for the identification of AIS using CXR, which are taken for health screening
  - Efficiency of early diagnosis and non-surgical treatment could be greatly improved

Conclusion

- Higher accuracy could be obtained using a deep learning model than by the passive measurement method based on the measurement of chest X-ray images

- Effectiveness of the early diagnosis and non-surgical treatment of scoliosis is expected to be enhanced through detailed examinations