Deep Convolutional Neural Networks for Automated Convulsion Scoring using RGB-D Images

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I. Introduction

- Rodent models, due to their small size, docility, and rapid breeding capability in captivity, have emerged as the primary choices for investigating the complex mechanisms underlying epileptogenesis, seizure generation, and subsequent suppression.
- We present a novel approach for automatic mouse behavior recognition in convulsion experiments using deep neural networks with RGB and depth (RGB-D) images, provided by MS Kinect® v2 2D/3D sensors.

II. Proposed Method

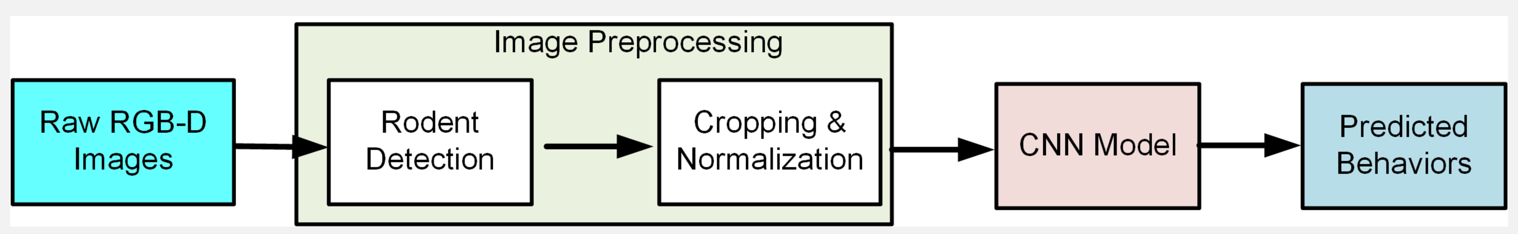

Fig. 1. The proposed framework and data flow for the automated mouse convulsion scoring.

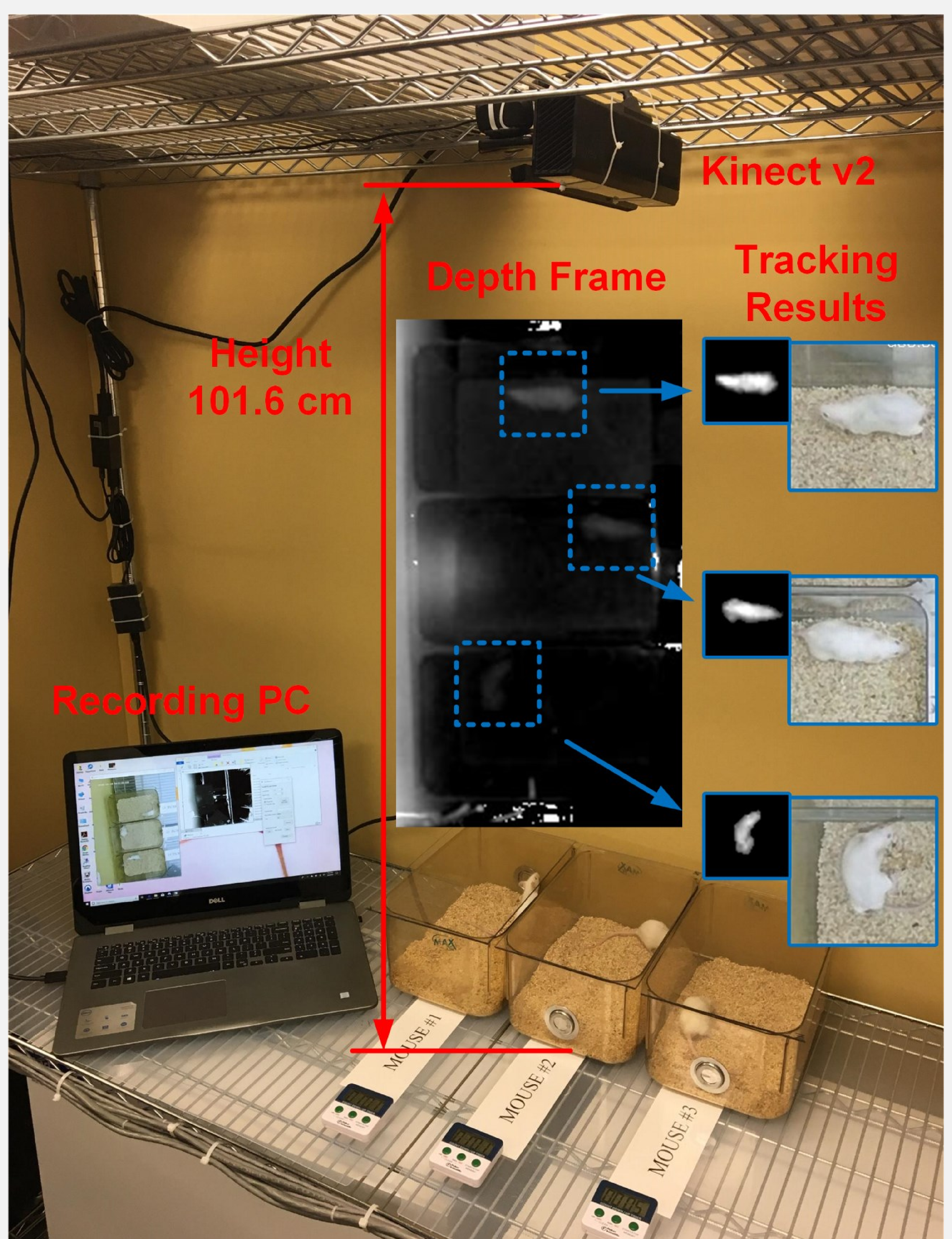

Fig. 2. Experimental setup for 3 simultaneous acrylic chambers with one animal per chamber.

Data Preprocessing

1. Raw depth images are used to locate the animal (mouse) by a rodent detector algorithm based on background subtraction.
2. The tracked coordinates are mapped from depth space (D) to color space (RGB), in order to generate mouse color crops.
3. Image crops are further pre-processed based on the requirements of each CNN model.

CNNs for Transfer Learning

1. Employing convolutional neural networks to extract high-level features directly from the image pixels enables transfer learning from existing CNN models, which are trained on large general purpose image datasets.
2. Two popular CNN architectures are examined: VGG-16 network and Inception-v3 network.

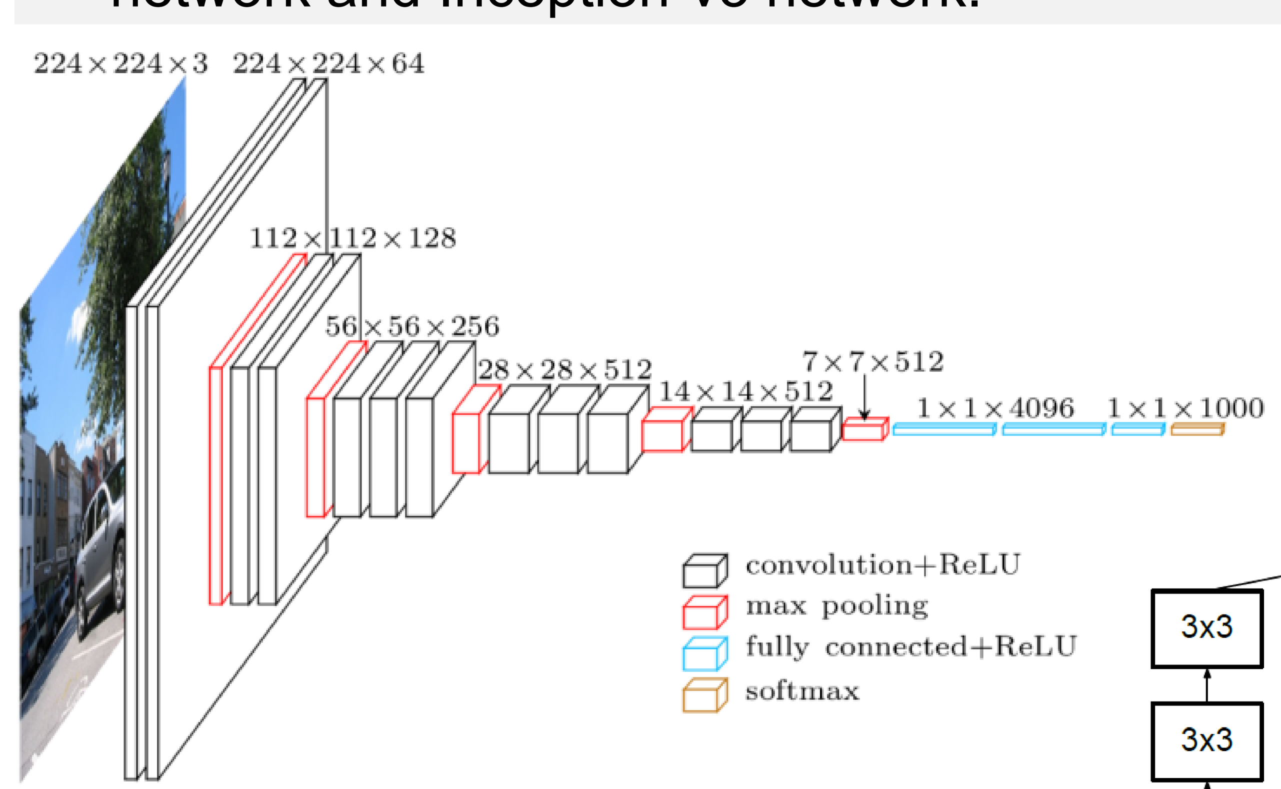

Fig. 3. VGG-16 Network

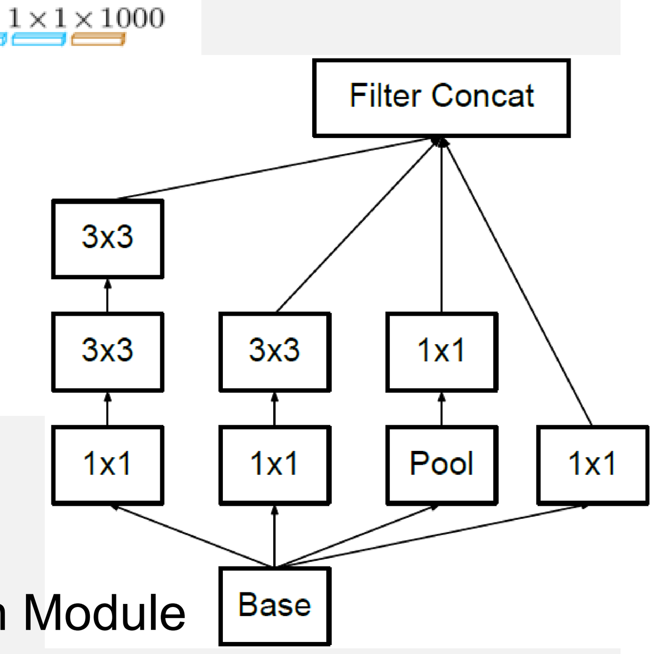

Fig. 4. Basic Inception Module

III. Experimental Results

- Dataset Collection:
  - RGB-D videos recorded on a total of 14 male Swiss Webster mice that weighed 27 - 33 grams and aged from 2 - 2.5 months.
  - The mice were injected with a specific dose of cocaine hydrochloride based on their weight, and then individually placed in acrylic chambers.
  - Each frame of the video was annotated as one of the mutually exclusive behaviors for convulsion soring, using the JWatcher software (www.jwatcher.ucla.edu/).
- Training Configuration:
  - Network weights initialized with the weights pre-trained on the ImageNet database (www.image-net.org).
  - Fine-tuned the whole model using stochastic gradient descent (SGD) with learning rate = 0.0001 and weight decay = 0.000001 till convergence.
  - Applied real-time data augmentation during training phase to compete with overfitting.

Table I. Classification Results of Each Method on Mouse Convulsion Dataset

Classification method		Training Set	Testing Set
SVM-based method		0.925	0.770
CNNs w/o Data Augmentation			
	VGG-16	0.985	0.852
	Inception-v3	0.998	0.835
CNNs w/ Data Augmentation			
	VGG-16	0.996	**0.898**
	Inception-v3	0.996	0.857

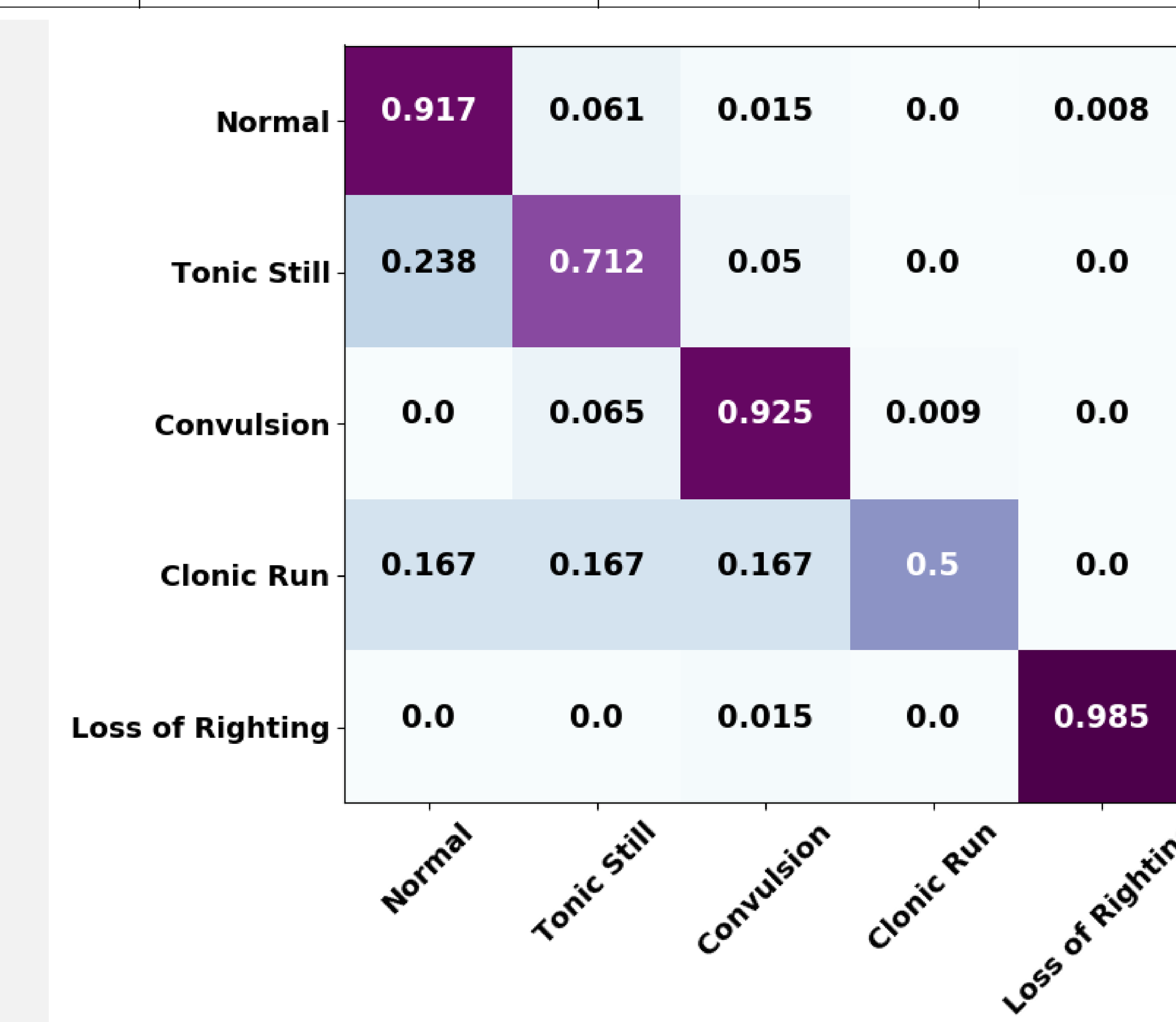

Fig. 5. Normalized confusion matrix of behavior classification results on testing set using VGG-16 network

IV. Conclusion

- Our model significantly outperformed the conventional SVM-based method, with the best results obtained using VGG-16 with data augmentation.
- Our future work involves combining features from preceding frames to integrate temporal information during model prediction.

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