（様式5）

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学位（博士）論文要旨

(Doctoral thesis abstract)

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論 文 題 目 (Title)	Handwritten Text Recognition by Deep Neural Networks 深層ニューラルネットワークによる手書きテキスト認識

論文要旨（2000 字程度）

(Abstract(400 words))

※欧文・和文どちらでもよい。但し、和文の場合は英訳を付すこと。

（in English or in Japanese）

This thesis presents deep neural network-based methods for offline handwritten text recognition, and Japanese historical document recognition. Offline handwritten text recognition is still a big challenging problem due to various backgrounds, noises, diversity of writing styles, and multiple touches between characters. In this thesis, we present models of Deep Convolutional Recurrent Network (DCRN) for recognizing offline handwritten text lines without explicit segmentation of characters. The DCRN model has three parts: a feature extractor by Convolutional Neural Network (CNN); an encoder by Bidirectional Long Short-Term Memory (LSTM); and a decoder by Connectionist Temporal Classification (CTC). We also propose two upgraded version of DCRN: Attention Augmented Convolutional Recurrent Network (AACRN) model which employs 1D self-attention mechanism in the encoder, and 2D Self-Attention Convolutional Recurrent Network (2D-SACRN) which introduces a 2D self-attention mechanism in the feature extractor to help the CNN to capture the relationships between widely separated spatial regions in an input image. Since the DCRN models require a large data for training, we synthesize handwritten text line images from sentences in corpora and handwritten character patterns in the handwritten character pattern database with elastic distortions. We conducted the experiments on three public datasets: IAM Handwriting (English), Rimes (French), and TUAT Kondate (Japanese). The experimental results show that the proposed model achieves similar or better accuracy when compared to state-of-the-art models in all datasets.

For Japanese historical document recognition, we present recognition of anomalously deformed Kana sequences, for which a contest was held by IEICE PRMU 2017. The contest was divided into three levels in accordance with the number of characters to be recognized: level 1: single characters, level 2: sequences of three vertically written Kana characters, and level 3: unrestricted sets of

characters composed of three or more characters possibly in multiple lines. This thesis focuses on the methods for levels 2 and 3 that won the contest. We employ the DCRN models for level 2. Then, we propose a method of vertical text line segmentation and multiple line concatenation before applying DCRN for level 3. We also examine a two-dimensional BLSTM (2DBLSTM) based method for level 3. Finally, we propose an attention-based sequence to sequence model named by Attention-based Row-Column Encoder-Decoder (ARCED) for both level 2 and 3 without explicit segmentation of text lines. The experimental results prove the performances of the proposed models on the level 2 and 3 tasks.

（英訳）※和文要旨の場合(400 words)