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Texture branch network for chronic kidney disease screening based on ultrasound images

Key words: Chronic kidney disease; Ultrasound; Texture branch network; Transfer learning

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Motivation

1. Early screening is the most effective measure to help prevent or delay the progression of the disease in chronic kidney disease (CKD) patients, and ultrasonography has become the preferred option for CKD examination.

2. For a radiologist, visually analyzing ultrasound images to identify kidney lesions is a time-consuming and challenging task.

3. Deep learning methods show great potential in computer-aided diagnosis recently.

Main idea

1. Texture features of ultrasound images are critical information, and they are often used for the computing tasks of kidney ultrasound images.

2. A feature fusion model is designed, which integrates deep features and domain texture features as multi-level description.

3. Transfer learning is used to train the model to reduce the risk of overfitting.

4. The proposed model is assessed by five-fold cross validation.

Method

1. A novel convolutional neural network framework is proposed, which consists of a base network and a texture branch.

2. The texture branch is organized as a residual structure, generating optimized texture features from the input image. At the end of the network, different types of features are fused for classification.

Major results

Texture branch network

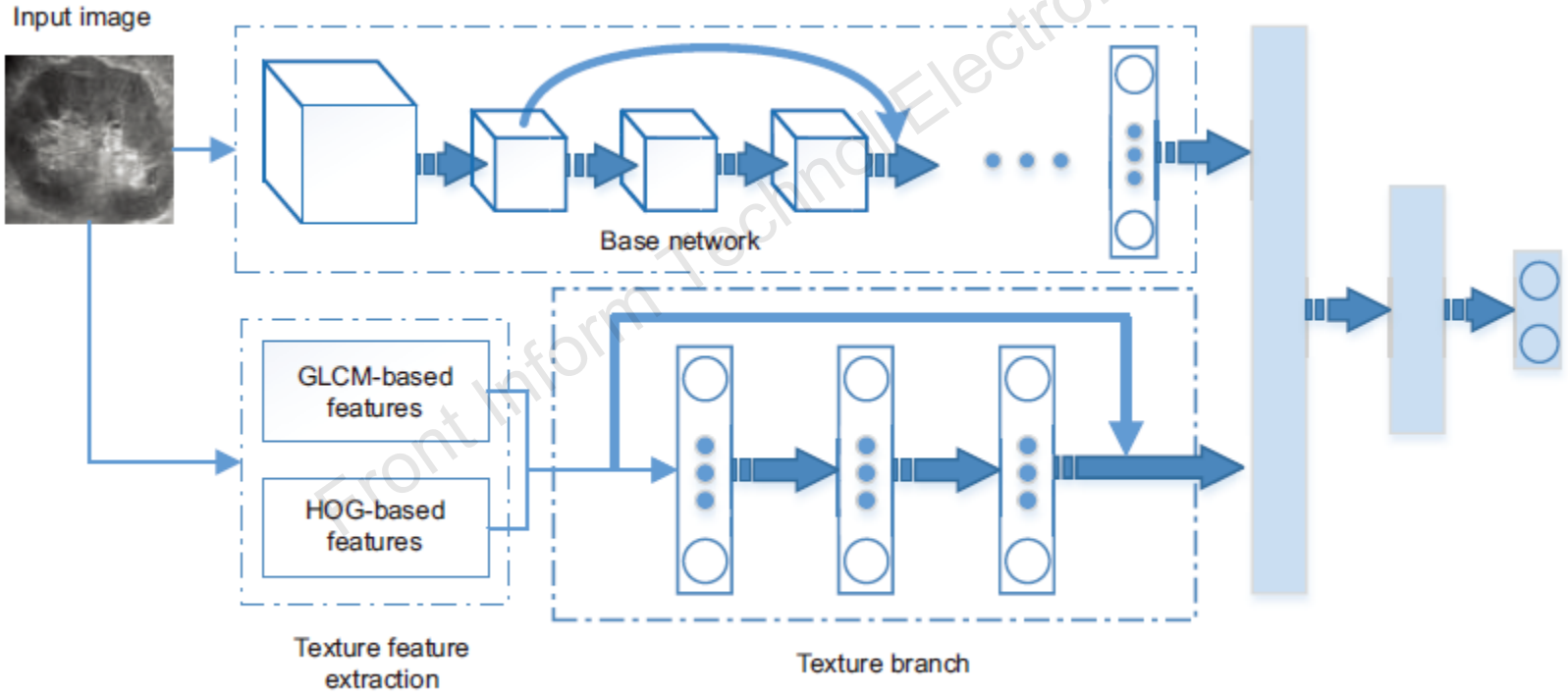

Fig. 1 Architecture of the proposed texture branch network (TBN) model

Major results (Cont'd)

1. Test results of our model and related methods

Table 3 Comparison of the performance of TBN with those of different texture branch and other related methods

Method	ACC (%)	AUC	SE (%)	SP (%)
ResNet-34 (S)	85.40	0.8914	91.67	60.87
ResNet-34 (T)	91.15	0.9498	96.67	69.57
Texture branch (H)	79.20	0.8344	82.22	67.39
Texture branch (G)	78.31	0.8208	79.44	73.91
Texture branch (HG)	79.65	0.8467	80.56	76.08
Zheng et al. (2019)	85.40	0.8818	90.00	67.39
TBN-H	93.36	0.9409	96.67	80.43
TBN-G	**96.01**	**0.9710**	**99.44**	82.44
TBN-HG	95.13	0.9688	97.22	**86.96**

ACC: accuracy; AUC: area under curve; SE: sensitivity; SP: specificity. The highest values are in bold

Major results (Cont'd)

2. Test results of using texture features under machine learning methods

Table 2 Classification performance of texture features under machine learning methods

Method	ACC (%)	AUC	SE (%)	SP (%)
LBP+SVM	67.72	0.7534	68.89	63.04
HOG+SVM	83.18	0.8850	87.79	65.22
GLCM+SVM	83.14	0.8746	87.22	67.39
HOG+GLCM+SVM	88.48	0.9096	92.22	73.91

ACC: accuracy; AUC: area under curve; SE: sensitivity; SP: specificity. LBP: local binary pattern; SVM: support vector machine; HOG: histogram of oriented gradient; GLCM: gray-level co-occurrence matrix

Conclusions

1. A texture branch network for ultrasound-guided CKD screening has been proposed, which uses a texture branch to extract texture descriptors and supplement the deep features from a CNN.

2. Under the limitation of an unbalanced small-sample dataset, the scheme of fusing texture features and deep features, combined with the training approach of transfer learning, showed an excellent classification accuracy.

3. Due to high sensitivity, the proposed method has the potential to be applied as computer-aided screening for CKD.

Fu-li WU, corresponding author of this invited paper, is an associate professor at Zhejiang University of Technology. He received his PhD degree from Zhejiang University, China in 2005. From 2006 to 2007, he was a post-doctor of the University of Bedfordshire. From 2012 to 2013, he was a visiting scholar of the University of California-Davis. His research interests include computer graphics, data visualization, and medical image processing.

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