12-12-2021

Decision Making and Social Interaction in the Medial Prefrontal Cortex: CNN Model for Classifying Chronic Pain Patients' Activated Brain Images

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Technology, Research, Education, Opinion

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Convolutional neural networks (CNN) are effective for the classification of medical (including brain) images. The medial prefrontal cortex (MPFC) is activated when an individual makes a decision or interacts with others (Euston et al., 2012; Grossmann, 2013). As pain is closely related to decision-making and social interactions, patients with physiological or psychological chronic pain tend to have gradually deteriorating MPFC regional functions (Xu et al., 2019), with varying degrees of activation in different brain areas (Quadt et al., 2020). This study intends to construct a CNN model to efficiently and accurately classify chronic pain patients' brain images by recognizing the different brain activation patterns that reflect either physiological or psychological pain. This study has collected brain images from the open database NeuralVault: 34 brain images reflecting psychological pain, 136 reflecting physiological pain, and 97 without pain. Since these images are highly confidential and expensive to acquire, only a small sample was collected. To compensate for the limited training data, data augmentation was applied during preprocessing to increase the dataset to 621 brain images for psychological pain, 837 for physiological pain, and 588 for no pain. Next, dropout was added to the model to improve the accuracy and avoid overfitting. As suggested by past studies (Bawa & Kuma, 2019; Eckle & Schmidt-Hieber, 2019), the model incorporated excitation functions and used ReLUs and sigmoid to solve the vanishing gradient problem. At this point, our trained model can effectively distinguish between psychological and physiological pain with an accuracy of 97%. The next stage of the study is to finetune the model to recognize MPFC images associated with decision-making and social interactions.

References

Bawa, V. S. & Kumar, V. (2019). Linearized sigmoidal activation: A novel activation function with tractable non-linear characteristics to boost representation capability. *Expert Systems with Applications*, 120, 346-356.

Eckle, K. & Schmidt-Hieber, J. (2019). A comparison of deep networks with ReLU activation function and linear spline-type methods. *Neural Networks*, 110, 232-242.

Euston, D. R., Gruber, A. J., & McNaughton, B. L. (2012). The role of medial prefrontal cortex in memory and decision making. *Neuron, 76*(6), 1057-1070.

Grossmann, T. (2013). The role of medial prefrontal cortex in early social cognition. *Frontiers in Human Neuroscience*, 7, 340. https://doi.org/10.3389/fnhum.2013.00340

Quadt, L., Esposito, G., Critchley, H. D., & Garfinkel, S. N. (2020). Brain-body interactions underlying the association of loneliness with mental and physical health. *Neuroscience & Biobehavioral Reviews*, 116, 283-300.

Xu, P., Chen, A., Li, Y., Xing, X., & Lu, H. (2019). Medial prefrontal cortex in neurological diseases. *Physiological Genomics, 51*(9), 432-442.