Toward Non-Invasive Neurochemical Wearables for Emotion and thought Analysis: Progress, Challenges, and Emerging Frameworks

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Abstract

The increased need to measure human emotions and mental states in objective and continuous and ecologically valid ways has further enhanced the evolution of wearable sensing methods. Traditional emotion recognition systems are largely based on behavioral or electrophysiological interfaces, which are an indirect manifestation of the neurochemical action of affective and cognitive mechanisms. Neurotransmitters, neuromodulators and stress-related biochemical markers are the basic regulating factors of emotions and thoughts, which has driven the development of non-invasive neurochemical wearables, which are able to record these factors without surgery.

New developments in both flexible electronics, electrochemical biosensing, and microfluidic sweat and sweat analysis have also facilitated the wearable permitting applications to identify biomarkers like cortisol, lactate, dopamine-associated lovable amounts, and electrolytes. These biochemical markers give firsthand information on stress, arousal, fatigue and motivational conditions, also providing a complementary information to conventional physiological and neural data. With artificial intelligence and Internet-of-Things (AIoT) infrastructure, neurochemical wearables allow personal and steady emotional and cognition tracking in natural settings.

This review is a synthesis of advances in non-invasive neurochemical sensing technologies and an analysis of the application in emotion and thought analysis. The materials of biosensors, signal transduction, and multimodal data fusion plans, along with portentous artificial intelligent inference pipelines are critically analyzed. Certainly, much attention is given to mental health systems, as over the past decades, anxiety disorders, obsessive-compulsive disorder, and attention-deficit/hyperactivity disorder are primary systems where neurochemical imbalances occur in the main problems. Existing issues with sensor selectivity, temporal resolution, individual differences between individuals, calibration drift, and the ethics are described in details.

Last but not least, new frameworks are discussed, including edge intelligence, federated learning, and digital neurochemical twins, which are putting features on the road to scalable, privacy ensuring deployment. Biochemical wearables will form the basis of the next-generation affect-aware system, neuroadaptive interface, and precision mental health by enabling the convergence of biochemical sensing with multimodal artificial intelligence.

Keywords

Neurochemical wearables, Emotion recognition, Cognitive monitoring, Sweat biosensors, AIoT, Mental health sensing.