

## A MULTI-CORE PROCESSOR BASED REAL-TIME MULTI-MODAL EMOTION EXTRACTION SYSTEM EMPLOYING FUZZY INFERENCE

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**ABSTRACT.** *Recently, researchers have paid close attention to human emotions to develop intelligent human-machine interfaces. Emotion extraction that considers only a single modality, however, has limitations, because each modality has its own weaknesses with respect to different emotions. Multi-modal sensing that mimics that employed by humans is, therefore, very important to improve extraction performance. We propose a multi-modal emotion extraction system based on fuzzy inference that is understandable to human beings. The system has a module-based hierarchical architecture in which the lower module handles emotion extraction independently for each modality, while the upper module integrates the results for all the modalities. Parallel processing is necessary for real-time processing of the multi-modal emotion extraction. We have implemented the proposed system on a multi-core processor, the “Cell Broadband Engine™” with multiple cores specialized for stream data processing. In this paper, we demonstrate the multi-modal emotion extraction system with two modalities, namely facial expressions and voice. Furthermore, to improve system performance, we propose a method to optimize fuzzy rules for facial expressions and voice using SOM clustering and statistical methods, respectively. The performance and validity of the proposed system are discussed based on the experimental results for emotion extraction of six basic emotions.*

**Keywords:** Emotion extraction, Fuzzy inference, Multi-modal sensing, Multi-core processor

**1. Introduction.** Human emotion plays an important role in establishing smooth communication in everyday life. Recently, the use of emotional information has attracted attention as a potential solution to improving the efficiency of human-machine interfaces. Such interfaces are useful for customer services, call centers, intelligent automobile systems, entertainment industries, and so on [1]. Sources for emotion extraction mainly include facial expressions [2-6], gestures [7], voice [8-10] and the corpus [11,12]. To classify an expressed emotion from a data source, machine learning algorithms such as neural networks [3,13], support vector machines [4,14] and HMMs [15] are typically used. However, machine learning algorithms generally have the following problems: 1) classification rules obtained by machine learning are difficult for humans to understand, 2) many training data are needed to train the network, 3) incremental learning to update the system is generally complicated. To extract human emotions, a human-like system that mimics that of human beings is very important. As a solution to the problems of machine learning, some researchers have proposed rule based emotion extraction methods. In other words, emotions are defined with words and represented by fuzzy if-then rules [16]. Razak et al. reported that emotion extraction using fuzzy inference gives a better recognition rate than a neural network method when the size of the training data is smaller [17].