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Methodology for stage lighting control based on music emotions

Shih-Wen Hsiao*, Shih-Kai Chen, Chu-Hsuan Lee

Department of Industrial Design, National Cheng Kung University, No. 1, University Road, Tainan 701, Taiwan

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ABSTRACT

Traditionally, stage lighting regulations have required that professionally trained technicians operate the lighting equipment; however, contemporary demands for higher-quality performances require more preparation before a performance. Thus, technicians or club DJs now spend double to triple the time previously required before a show on matching the lighting control sequence musical instrument digital interface (MIDI) with the music, which is very time consuming. Thus, a methodology for automatic stage-lighting regulation would be very useful. Recently, the development of music emotion recognition (MER) and neural network algorithms has progressed significantly. Feelings related to music can be recognized and are even quantifiable using a supervised machine learning approach. In this study, a variety of music signal features from 2,087 song clips were captured, and then, a cross-validation test based on the support vector machine's (SVM) accuracy of classifying them into Thayer's emotion plane was applied to the main features related to music emotions, in order to produce linear quantitative values for describing music emotions. Music emotions and color preferences for stage lighting were subsequently studied. Using the experimental results, a support vector regression (SVR) model was trained to construct simulations. To increase the realism of the simulations, we developed an automatic music segment detection methodology based on music signal intensity to capture the different music strengths and feelings in each segment. Furthermore, music genres were studied as a factor for developing a comprehensive automatic stage lighting system based on feelings, genre, and the intensity of each segment of music.

1. Introduction

Traditionally, stage lighting regulations have required that professionally trained technicians operate the lighting equipment. However, with rising labor costs, most technicians are now required to control both light and sound. Existing systems can use quantifiable signal features to adjust the stage lighting parameters. However, music feelings are abstract, as are lighting and color feelings, and therefore, it is difficult to build a computer simulation and automatically generate the lighting and color that reflect these feelings. The development of music emotion recognition (MER) and neural network algorithms has recently progressed significantly. Feelings evoked by music can now be recognized in a more scientific manner; they have even become quantifiable by means of a supervised machine learning approach. In addition, studies on color emotions have indicated that light and color can influence people's perceptions and emotions. Overall, it seems that the development

* Corresponding author.
E-mail addresses: swhsiao@mail.ncku.edu.tw, swhsiao2002@yahoo.com.tw (S.-W. Hsiao).

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of an automatic lighting regulation system based on feelings, genre, and the intensity of each segment of music is no longer impossible.

1.1. Music emotions

Research on music and emotions has a long history. In recent years, MER has undergone significant development. A typical approach is to choose several adjectives that express emotions and use a property classification algorithm to recognize different music emotions [7,20]. Although the use of this approach has become widespread, researchers face a problem: it is difficult to use a small number of adjectives to cover all possible music emotion expressions. Furthermore, people having different cultural backgrounds interpret adjectives differently. Therefore, researchers have started to seek a general and efficient means of expressing music emotions. An emotion model, known as the Thayer model, which is based on linear and continuous emotion expressions, is now frequently used. This model, which is described in detail below, uses two consecutive values: valence (indicating positive or negative emotions) and arousal (the energy degree of an emotion) to define a plane covering the expressions of human emotion. For example, many studies have used a support vector machine (SVM) to classify music into the four quadrants of the Thayer model [24,49]. When these types of emotion expressions are used, it is not necessary to strictly define each music emotion by a particular adjectival term. Therefore, even people from different cultural backgrounds can easily understand the terms. Meanwhile, the Thayer model allows emotions to be expressed as two linear values, which is very convenient for computer applications. However, it is very difficult to analyze the impact of music emotion classification or to construct a computer simulation regressively.

Since neural network-supervised learning machines have reached a mature phase of development, the use of a regression approach has gradually become a trend in current research on music emotion recognition. In one study, 253 subjects were invited to listen to 10 music clips randomly selected from 195 pop song clips and to give them emotional values [49]. Yang subsequently used the experimental results to train several supervised learning regression algorithms; the validation results showed that the trained support vector regression (SVR) model output had the highest statistical correlation coefficient [49]. However, the validation results were not outstanding, an outcome that could have been caused by the small amount of data derived from the experiment.

In the SVR approach, a supervised learning algorithm is used to simulate music emotion regressively. Instead of a small amount of experimental data, a large amount of music information derived from social network Web data is used as the training data. In order to reduce the errors caused by relying solely on the subjective personal perceptions of a few subjects, the current trend is to conduct experiments using a large number of users. This approach should enhance the accuracy of music emotion simulations, allowing the relationship between music emotions and lighting regulation according to its properties to be studied in depth.

1.2. Lighting colors and emotional feelings

Colors carry both messages and images. They have different significance for people having different cultural backgrounds. Currently, researchers are using the Kansei Engineering measurement approach to describe or measure "the amount" of emotions people feel [29]. This approach has enabled researchers to interpret abstract color imagery feelings numerically. Recently published studies on color emotions have focused on the selection of emotional scales and on investigating the manner in which these scales are related by using factor analysis. Regression analysis is usually applied to reveal the relationships of human responses; herein, the scales describe the underlying color appearance attributes, such as lightness, chroma, and hue. In many studies, researchers have advanced to applying their methods [11], and with the mature development of computer-aided design, in these studies computer-aided design color plans for products or clothes based on eliciting specific emotions have been developed [9,10,11]. Light and color can influence people's perception of the characteristics of the area around them, such as its comfort and atmosphere; they can even cause the pulse and endocrine activities to accelerate [28]. These studies indicated that the regulation of light can trigger specific emotions and affect the excitement level of an audience, and a specific color can be associated with emotional feelings in a specific atmosphere. Thus, it is reasonable to arrange an appropriate lighting regulation based on music emotions.

2. Related work

2.1. Emotion model

MER has recently been significantly developed [24,26,49]. In almost every related study, emotions were defined differently. Scholars have used a number of adjectives to describe some of the basic emotions [16,41,38]. In addition, Li and Ogihara [22] presented 13 classifications for different types of emotions, including 11 taken from Farnsworth's research [6]; they added the remaining two types. They sought a definition that would cover all the expressions of music emotions. However, their results were not very convincing; the small sample of people who labeled the music under consideration reduced the reliability of their study results. Therefore, in many studies on music emotion recognition, psychological research on music, as a theoretical background, is now employed to find relevant expressions to define emotions. Some adjectives, such as "delicate," "charming," and "gloomy," are used frequently. However, the total number of adjectives used to describe