AUTOMATIC RECOGNITION OF FACIAL EXPRESSIONS USING HIDDEN MARKOV MODELS AND ESTIMATION OF EXPRESSION INTENSITY

by

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Submitted to the Graduate Faculty
of the School of Engineering
in partial fulfillment of
the requirements for the degree of
Doctor
of
Philosophy

1998

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ACKNOWLEDGEMENTS

I am greatly indebted to Professor Takeo Kanade and Professor Ching-Chung Li, my co-advisors and my mentors, for not only providing invaluable guidance, advice, criticism and encouragement but also giving me the latitude I have needed to develop as a researcher. I thank Professor Jeffrey Cohn, co-advisor, for his support and teaching with the Facial Action Coding System (FACS). I would also like to thank the other members of my thesis committee: Professors Richard Hall, Morton Kanefsky, Marwan Simaan and Henry Chuang for their valuable suggestions and feedback.

My years at the Vision and Autonomous Systems Center of the Robotics Institute, Carnegie Mellon University have been priceless. I consider myself lucky to be a part of this research center and spend many nights with friends discussing technical issues. I would like to thank Jie Yang and Michael Nechyba for sharing their experiences with Hidden Markov Models; Conrad Poelman, Richard Madison and Yalin Xiong for exchanging knowledge on optical flows; Peter Rander, Henry Rowley, Shumeet Baluja, Teck Khim, Wei Hua, Mei Han, Mei Chen, Dongmei Zhang, Michael Smith, Daniel Morris and Farhana Kagalwala for much needed help; and Adena Zlochower for her help with FACS on the facial expression analysis project. My thanks also go to Chung-Hui Anne Lin for her support and encouragement. I would especially like to thank David LaRose and Yu-Te Wu, who have been tremendous fun to work and play with, and who have provided countless hours of invaluable discussions on the topics presented here.

Special thanks to Matthew Turk, Steve Shafer, P. Anandan, Richard Szeliski and Harry Shum at Microsoft Vision group for their valuable comments and suggestions.

Finally, I would like to thank my parents, Chin-Chuan Lien and Wen-Hua Shih, as well as my other family members: Jenn-Ren Lien, Jenn-Yueh Lien, Shu-Hua Chien, Hui-Yin Christia Tien for their constant love, support and encouragement. Without them, none of this would have been possible. I cannot begin to thank them enough, and they will always have my respect and love.
ABSTRACT

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AUTOMATIC RECOGNITION OF FACIAL EXPRESSIONS USING HIDDEN MARKOV MODELS AND ESTIMATION OF EXPRESSION INTENSITY

Jenn-Jier James Lien, Ph.D.

Facial expressions provide sensitive cues about emotional responses and play a major role in the study of psychological phenomena and the development of nonverbal communication. Facial expressions regulate social behavior, signal communicative intent, and are related to speech production. Most facial expression recognition systems focus on
only six basic expressions. In everyday life, however, these six basic expressions occur relatively infrequently, and emotion or intent is more often communicated by subtle changes in one or two discrete features, such as tightening of the lips which may communicate anger. Humans are capable of producing thousands of expressions that vary in complexity, intensity, and meaning. The objective of this dissertation is to develop a computer vision system, including both facial feature extraction and recognition, that automatically discriminates among subtly different facial expressions based on Facial Action Coding System (FACS) action units (AUs) using Hidden Markov Models (HMMs).

Three methods are developed to extract facial expression information for automatic recognition. The first method is facial feature point tracking using the coarse-to-fine pyramid method, which can be sensitive to subtle feature motion and is capable to handle large displacements with subpixel accuracy. The second is dense flow tracking together with principal component analysis, where the entire facial motion information per frame is compressed to a low-dimensional weight vector for discrimination. And the third is high gradient component (i.e., furrow) analysis in the spatio-temporal domain, which exploits the transient variance associated with the facial expression.

Upon extraction of the facial information, non-rigid facial expressions are separated from the rigid head motion components, and the face images are automatically aligned and normalized using an affine transformation. The resulting motion vector sequence is vector quantized to provide input to an HMM-based classifier, which addresses the time warping problem. A method is developed for determining the HMM topology optimal for our recognition system. The system also provides expression intensity estimation, which has significant effect on the actual meaning of the expression.

We have studied more than 400 image sequences obtained from 90 subjects. The experimental results of our trained system showed an overall recognition accuracy of 87%, and also 87% in distinguishing among sets of three and six subtly different facial expressions for upper and lower facial regions, respectively.
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