IEEE WCCI 2014 Tutorial on

Computational Intelligence and Machine Learning for Affective Computing

Affective computing (Picard, MIT Media Lab, 1997) is "*computing that relates to, arises from, or deliberately influences affects*." It has been gaining popularity rapidly in the last decade (see Figure 1) because it has great potential in the next generation of human-computer interfaces.

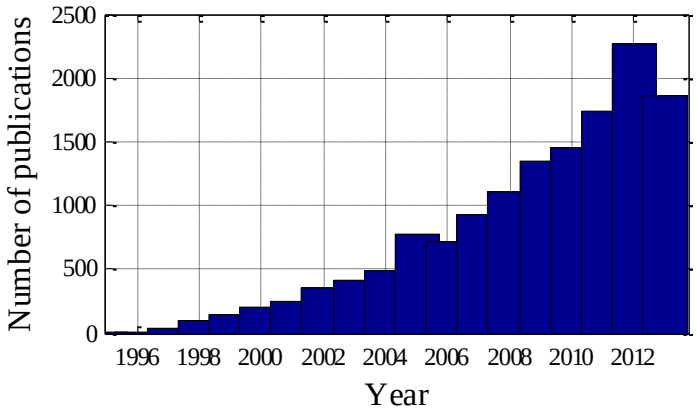

Figure 1. Number of Google Scholar publications on affective computing since 1995.

One goal of affective computing is to design a computer system that responds in a rational and strategic fashion to real-time changes in user affect (e.g., happiness, sadness, etc), cognition (e.g., frustration, boredom, etc) and motivation, as represented by speech, facial expressions, physiological signals, etc. Its applications include:

- *Companion devices*, e.g., robots which interact with people using emotional intelligence, which are in line with President Obama's National Robotics Initiative, and are particularly promising in Autism therapy.
- *Personalized learning*, which makes learning more effective by individualizing instructions based on learning styles, speeds, interests, and emotional/cognitive states. It is one of the 14 Grand Challenges identified by the US National Academy of Engineering.
- *Ambient intelligence*, which are electronic environments sensitive and responsive to the presence of people. It is built upon pervasive/ubiquitous computing, context awareness, and human-centric computer interaction design.
- *Health services*, which benefit from knowing in real-time a client's cognitive and emotional states, estimated from physiological signals recorded in everyday life by portable devices.

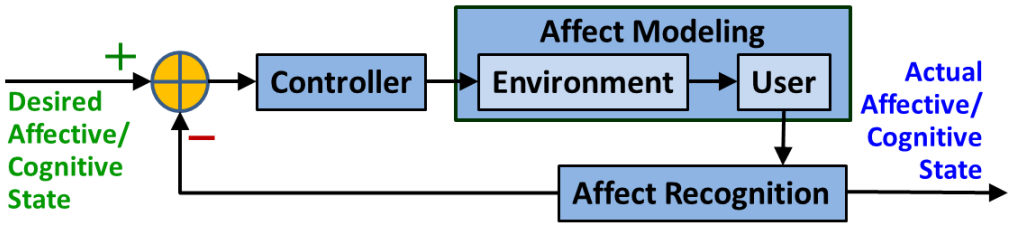

Figure 2. Diagram of a closed-loop affective computing system.

A closed-loop affective computing system is shown in Figure 2. It consists of three modules: *affect recognition*, which is to recognize the user's affects from various body signals; *affect modeling*, which is to model the relationship between the environment surrounding the user (e.g., music, lighting, temperature, traffic, etc) and the change of the user's affects; and, *affect controller*, which outputs appropriate control signals to change the environment surrounding the user and hence to influence the user's affect for healthier and more productive living. Various technologies, including *signal processing*, *machine learning*, *data mining*, *knowledge management*, *decision making*, *cybernetics*, and *optimization*, are needed in building such a system.

We believe computational intelligence techniques can play a very important role in affective computing. Fuzzy logic systems in particular provide a highly promising avenue for addressing some of the fundamental research challenges in affective computing where most data sources, e.g. EEG, ECG, skin conductance, respiration, facial expressions, speech, and gesture, are very noisy/uncertain and subject-dependent. Neural networks, especially deep neural nets, are very promising tools for both feature extraction and affect recognition. Last but not least, evolutionary computation is very valuable for optimizing all recognition algorithms.

The goal of this tutorial is to introduce affective computing, an exciting new research area, to broader audience of the computational intelligence society, and show how computational intelligence techniques, especially fuzzy logic, can be applied in all three modules in Figure 2. We will also introduce some recent machine learning techniques, including deep learning, active learning, and transfer learning, and show how they can be used in affect recognition to handle individual differences.

Tentative Outline:

1. Introduction
2. Applications of Affective Computing
3. Computational Intelligence in Building Closed-Loop Affective Computing Systems
    a. Affect Recognition
    b. Affect Modeling

    c. Affect Control
4. Machine Learning in Affect Recognition
    a. Deep Learning
    b. Active Learning
    c. Transfer Learning
    d. Examples
5. Conclusions

Length: 2 hours

URL: https://sites.google.com/site/drwu09/services/wcci-2014-tutorial

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Bio: Dongrui Wu received a B.E in Automatic Control from the University of Science and Technology of China in 2003, an M.Eng in Electrical and Computer Engineering from the National University of Singapore in 2005, and a PhD in Electrical Engineering from the University of Southern California (USC) in 2009. He was a Research Associate in the USC Institute for Creative Technologies and Signal Analysis and Interpretation Laboratory. He is now with the Machine Learning Lab, GE Global Research, Niskayuna, NY.

Dongrui Wu's research interests include affective computing, computational intelligence, intelligent control, machine learning, optimization, speech and physiological signal processing, and conventional and renewable energy. Dongrui Wu has 70 publications, including a book "Perceptual Computing" (with J.M. Mendel, Wiley-IEEE, 2010). They have accumulated over 1800 citations on Google Scholar. Dongrui Wu received an IEEE International Conference on Fuzzy Systems Best Student Paper Award in 2005, an IEEE Computational Intelligence Society (CIS) Outstanding PhD Dissertation Award in 2012, and IEEE Transactions on Fuzzy Systems Outstanding Paper Award in 2014. He was one of the 200 selected young researchers worldwide to meet 39 Abel/Fields/Turing laureates at the 1st Heidelberg Laureate Forum in 2013. He has received 4 Above and Beyond Awards from GE Global Research for outstanding performance.

Dongrui Wu has been an Associate Editor of IEEE Transactions on Fuzzy Systems since 2011. He is a Guest Editor of the IEEE Computational Intelligence Magazine Special Issue on Computational Intelligence and Affective Computing, an Executive Committee member of the Association for the Advancement of Affective Computing (AAAC), and a member of the IEEE CIS Fuzzy Systems Technical Committee, Emergent Technologies Technical Committee, and

Intelligent Systems Applications Technical Committee. He was Chair of the IEEE CIS Affective Computing Task Force in 2012, and Vice Chair in 2013.