

A Multi Agent System Analyzing Parameters Related to Facial Expressions

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ABSTRACT

We present a multi agent system to generate society profile about facial expressions. Each user interacts with its User Interface Agent which collects user information and communicates with the other agents in the system. A graphical facial animation program is used to monitor facial expressions and to allow the user to draw his/her expressions. The information processed in the system is the parameters related to facial expressions. The parameters are processed for generating general society profile and local agent beliefs according to facial expressions generated by users and the grades assigned to expressions. The society profile is generated by an intelligent agent, called Clustering Agent having ability to cluster all the agent information in the system. The Clustering Agent learns some parameter weights used in the clustering process by the rewards of the users. The system may be a useful tool for multimedia applications, including advertisements, games, and entertainment.

KEY WORDS: Intelligent agents, clustering, learning, facial expression analysis, multimedia applications.

1. INTRODUCTION

Analyzing facial expression, an important tool of human communication, is one of the most attractive field of social sciences. Analysis of human face and facial expressions is also important for computational efforts. Many applications have one of the requirements of either the recognition of faces of persons, or the reconstruction of faces. Some researchers in the fields of computer graphics and pattern recognition have proposed many works including analyzing and synthesizing facial image sequences [1], talking facial display generation by analyzing visemes [2], and facial expression analysis by using Ekman and Fiersen's FACS coding system [3].

Nonverbal communication among autonomous characters such as synthetic agents, virtual actors, and avatars is as important as text based communication. The facial expression plays an important role for nonverbal communication [4]. Facial expressions should be carefully analyzed for natural and believable visual interaction is possible among artificial characters. Some applications statically determine some facial expressions such as, happiness, sadness, fear, surprise, and anger. Some environments consisting of real and artificial agents or characters may require nonverbal communication by facial expressions. Synthetic character training can be implemented by using facial expressions. Teachers (as an artificial character like Dr. J. Puppet in [5]) of some synthetic characters may represent some facial expressions related to the behaviors of learners. A sociable humanoid robot Kismet [6] communicates with people by using sensory information and represents some facial expressions related to her emotions. Such an another robot, Feelix, has static facial expression information [7]. Maes' work on the effects of personification of agents discusses the importance of facial representations of agents in a poker game [8]. The results of this work show that while the caricature character of a dog is more likable than the other representations, the realistic agent's facial expressions are more tractable, and this agent has more intelligence than the other subjects. In her work, the expressions are statically determined. Pixar Animation Studios animators work carefully on the facial expression generation of artificial characters, and this part is the most important and the last phase of the character generation process[9]. Some researchers writing multimedia programs are focused on interface agents [10]. These agents assist users by observing them or taking feedback from them. The aim is either assisting users or increasing effectiveness level of usage. These agents are responsible for generating user's profile for further processes. User Interface Agents work as intelligent units in many systems including mail filtering, recommendation [11], information broadcasting or management systems [12],[13]. User preferences and requests are learned by user interface agents, and this information is exchanged among the agents.

Although there is no standard definition of the term, an agent is situated in some environment and capable of autonomous action in this environment in order to perform its task [14]. Every agent has different talents and tasks related to the application. Simulating nature and natural processes requires designing artificial agents similar to a live agent, human. If agents do not have significant effects on its environment it is not necessary to implement them as intelligent units. In this case, coordinated and consistent multi agent systems are used. There are differences between multi agent systems and personal agent systems [15]. Multi agent systems analyze not only one of the agents' information related to its user but also information of the other societies. The agent in the multi agent system stores knowledge about its user and the environment.

In our system, we propose a multi agent system for generating society profile by using the user profile agents' information. The aim of the work is to use the proposed system to determine some control parameters of an animated face for some situations dynamically. The overall system work is done by cooperating agents living in the system. Consequently general beliefs of society and some exception situations related to facial expressions are represented by clusters. The system is suitable for communicating with other systems' agents by KQML messages.

Results of this work may be used in social sciences and also in entertainment and multimedia applications. We believe that learning necessary parameters for facial expressions will be useful for pedagogically diagnosing of some disabilities, determining some cultural differences on facial expressions among nations or groups of users, generating facial expressions for some artificial characters, and generating facial transitions for agents reading stories or news. Our system may also be used as a facial monitor for displaying parametrical components of some measurements such as system performance, by the parametrical background of facial expressions.

In this paper, the detailed overview of our system can be found. The components of the system are implemented and tested. The social results of our work has not yet been considered. These results are out of the scope of this paper.

2. ANALYSIS OF FACIAL EXPRESSIONS

Some personal services such as news telling, or advertisement can be improved by generating facial expressions according to the information taken from users. The way that they are served may be determined by the user's personal preferences. However this is a kind of process that consumes resources and decreases system performance. This service should be provided by grouping users according to their ages, preferences, or requests, etc. The users acting similar behaviors are considered. This is ensured by clustering users with similar preferences. Thus, people belonging to the same group may be served similarly.

In our system, facial expressions are generated by users (children) for some questions. These questions are determined by pedagogical experts. Questions may be sentences from a story or some other special situations. A general question set is considered for covering many facial expressions. A sample question is like: "Could you please draw me a picture of a child punished for cheating." This question is asked all of the users. Every user draws his/her facial expression according to this situation. A collection of facial drawings for many situations is collected. According to this information society profile is generated, and the user drawings are clustered. Therefore, the facial expression analysis results show the similar expressions and the exceptions according to the clusters.

3. THE OVERALL SYSTEM

The system consists of users, User Interface Units (UIUs) consisting user interface agents (UIAs) communicating with users, a Clustering Agent (CA) responsible for generating society profile, existing multi agent system library and architecture components.

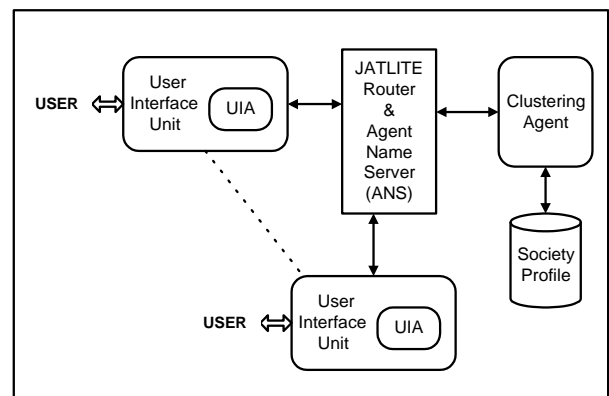


Figure 1. The Overall System Diagram

Every user interface agent in the system communicates with its user at both directions. On the registering of each user a user interface agent representing him/her is created. The UIA is responsible to form user profile, and to interact with the other agents in the system. A Clustering Agent is alive on every phase of the system, and it interacts with all of the user interface agents in the system.

Our aim is allowing users to generate facial expressions for some situations, to exchange this information among them, and to give grades to the others' facial expression drawings. Thus, some general forms of facial expressions are determined by users and their agents. The results are obtained in the form of clusters of parameters related to facial expressions.

Every UIU is created on each user's machine. Every user registers to the system from different machines in a LAN

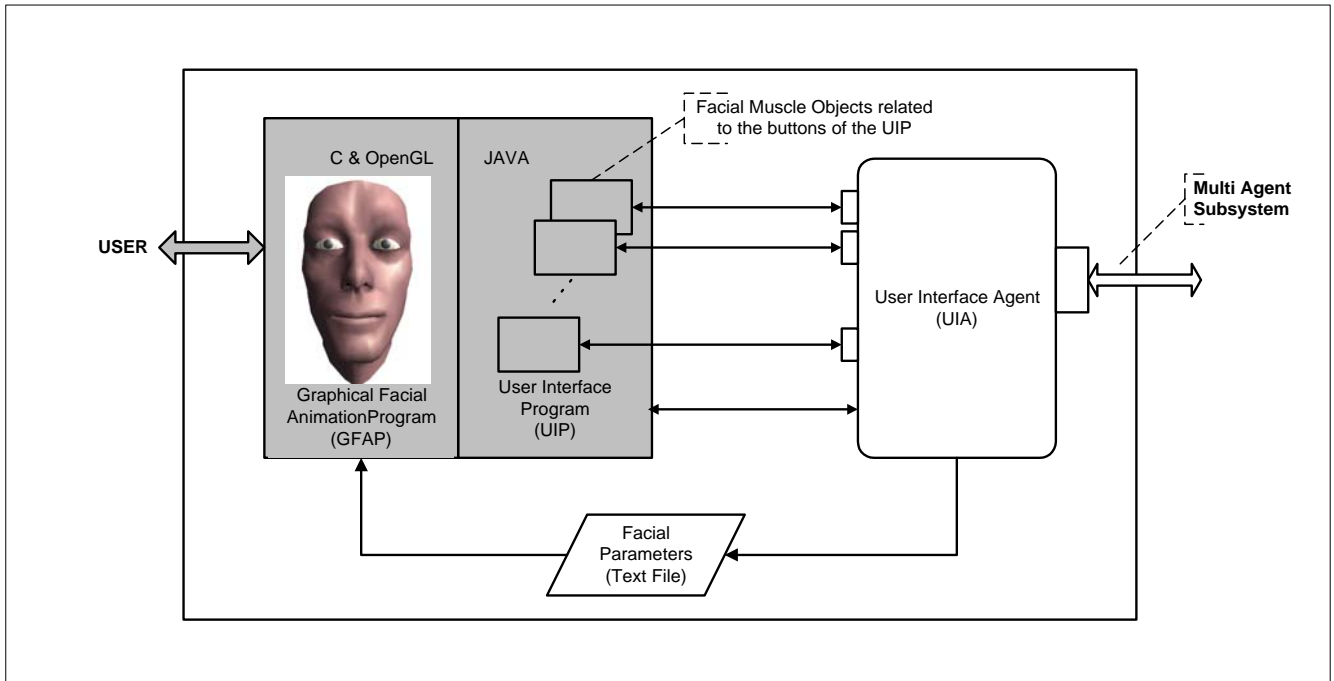


Figure 2. The User Interface Unit(UIU)

or an internet environment. Each UIU components, which will be explained in the following sections, may live on different machines but they are logically assigned to one user. The JATLITE Router, the address of which all of the agents registering to the system should know, may be located anywhere. Clustering Agent may live on any machine in the environment.

Our system is similar to the system presented by David and Kraus [12]. In their system, user preferences and interest areas are considered, and user communities are formed based on this information. The aim of that system is to produce multimedia programs according to the integrated user profiles. However their proposed system considers document information.

3.1. THE USER INTERFACE UNIT

The User Interface Unit (UIU) communicates with the user. The UIU consists of The User Interface Agent (UIA), The User Interface Program (UIP), and The Graphical Facial Animation Program (GFAP). The UIU requires cooperation among its components to operate.

Each UIA requests from its user to draw facial expressions for some situations. The user generates these facial drawings by using buttons on the display of the UIP. Facial muscle objects related to the buttons request service from UIA. The communications between the UIA and the facial muscle objects are synchronous and implemented on different ports of the UIA. Facial muscle objects are modeled as reactive agents. UIA serves for

different behaviors of facial muscle objects. Protocol definitions are known for both sides. The UIA gets the requested behavior and updates a text file related to it. The GFAP uses this text file as an input according to the information taken from muscle objects. The GFAP reads the text file within certain intervals and displays the facial expressions related to the updated parameters. After determining some

facial expressions for some situations, every UIA in the system stores its user's information. This information is sent to the Clustering Agent to generate society profile.

After sending user information to the CA, the UIA interacts with the other agents in the system. The information exchanged among agents is the parameter values for facial expressions. These parameter values are written by the UIA to the text file for generating facial drawings. Therefore the facial expressions drawn by other users can be shown to the user. Then, the user grades these drawings. Every UIA in the system has an influence constant. This value indicates how much this UIA's beliefs will be affected by the others' information. Each UIA belief is created by the user information and the grades about the others' information. Facial parameter weights are learned by the UIA according to the grades.

The UIA stores the information obtained from peer agents and processes it for clustering depending on the value of the influence constant. Thus, the general belief of the UIA about society is created. The UIA beliefs and the society profile will all be different as in nature because of the random interaction and influence constant of UIA's.

The User Interface Program

The User Interface Program (UIP) performs user-agent interaction. It is, written in Java, a subclass of the User Interface Agent. It generates a window to communicate with the user at both directions. User gets questions from the display of the UIP. Then the user is able to change the expression of the GFAP. The user's feedback is also taken via this program.

The facial muscle objects are related to the buttons of the UIP. These objects are responsible for the movement of certain muscles of the face. They are unintelligent reactive agents. The User Interface Agent acts as a facial updating server. Each facial muscle object communicates with this server on a certain port synchronously.

The Graphical Facial Animation Program

The Graphical Facial Animation Program (GFAP) is a facial animation program representing a parameter set for a facial expression. Parametric analysis of facial animation and expressions is first proposed by Parke. Image generation is based on surfaces constructed from connected networks of polygons in the model he represented [16]. The advantage of using parameterized models is changing facial expressions by using only parameters. Such a work is implemented by K. Waters [17] This is a C program using OpenGL. In this program, 3D dynamic model of the face is represented. This face model combines a physics-based model of facial tissue with an anatomically based facial muscle control process to synthesize realistic facial motions. The parameters related to the muscles on the non-uniform triangular mesh model can be manipulated, and the facial expression of the program is changed [1]. We used the implementation of Waters in our system. The parameters are the information considered and exchanged during the system work in our system. There are 18 parameters related to muscle control points. They are: Left and right Zygomatic_Major, Left and right Angular_Depressor, Left and right Frontalis_Inner, Left and right Frontalis_Major, Left and right Frontalis_Outer, Left and right Labi_Nasi, Left and right Inner_Labi_Nasi, Left and right Lateral_Corrigator, Left and right Secondary_Frontalis. All of them are controlled by the user.

We needed some manipulations on this program for our system. The original program uses parameters changed by the user with keyboard instructions. It uses the Glaux [18] Library which does not support timer function. In our system, the parameter values are changed by user interrupts. The text file consisting of facial parameters is updated according these interrupts. Therefore new facial parameters should be read at certain time intervals to show the updates on the facial model of GFAP. To integrate our UIP with the GFAP, timer function should have been added. So the program is converted to use Glut Library [18] consisting timer function and supporting the texture mapping.

The User Interface Agent

The User Interface Agent (UIA) is the interactive part of the UIU. The User Interface Agent as an autonomous entity collects its user's information and uses it for further processes. It is implemented as a JATLITE agent. It has ability to communicate and to exchange information with other user agents in the system. The information exchange is done by using KQML messages. This information is used for generating agent beliefs by taking feedback from users. The UIA communicates with the facial muscle objects and updates related parameters, according to the user instructions. The UIA outputs the parameters to a text file which the GFAP uses as an input to generate the facial drawings of the user.

The UIA is responsible for generating agent beliefs according to the user drawings and the grades of the others' drawings. The agent determines own parameter weights according to the grades. Each UIA has an influence constant. This value determines how much this agent relies on the other agents. This constant is assigned initially to the agent. The agent forms its beliefs according to this constant and the information about facial expressions.

3.2. THE MULTI AGENT SUBSYSTEM

The system is modeled as a multi agent system. Each user has an artificial agent. Agent construction and communication are supported by JATLITE [19]. JATLITE includes a Router unit which implements agent registration processes and serves as a Naming Server. Therefore agent names and addresses are accessible for any other agent in the system. Although the receiver agent is off-line messages are stored by queuing and polling service of the Router. Two agents communicate with each other either through Router or directly by learning addresses from the Router. The agents in the system should know the address of the Router. Each user (agent) registers to the system with a user name and a password. Every agent has a unique name in the system by agent name serving facility of the Router. The system is scalable. Every agent in the system is loosely connected to each other. Leaving of an agent from the system or coming of a new one does not influence the system performance.

Our system uses the KQML [20] layer of JATLITE for inter agent interaction. KQML messages are based on speech-act theory. Standard KQML primitives are used in communication. This feature provides communications among different systems.

3.3. THE CLUSTERING AGENT

The Clustering Agent (CA) is an intelligent agent having ability to learn parameter weights from its environment,

to cluster the data, and to form society profile. This agent processes the KQML messages sent by all the agents in the system to determine general beliefs of the society. The CA clusters data dynamically.

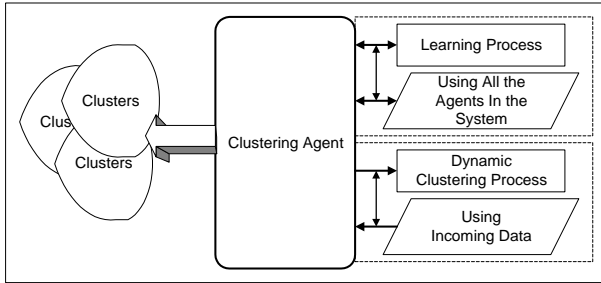


Figure 3. The Clustering Agent Processes and Its Interaction with the Environment

The Clustering Process of Facial Expressions

Each muscle parameter on the facial drawing has been used as one dimension in a multi-dimensional space. To improve effectiveness of the clustering process, the CA learns facial parameter weights based on other agents' information for using them in the parameter reduction phase. The question is which parameter contributed to what extent of the facial expression. The CA interacts with its environment by using its sensory input, messages coming from the UIA's in the system. It sends a random facial expression for each situation to a random UIA and requests from a user via its UIA to assign a grade for this expression. In the environment, the users act as critics for the learner. The grades are rewards or punishments for the expressions. The CA regulates the current facial expression according to the grade and sends it to another user. The user society is a dynamic and non-deterministic environment. Because different users assign different grades to the same facial expressions, the same state and action pair does not result from the same reward. To implement the learning task, many trials are needed. After CA learns the facial parameter weights, the feature reduction process is completed for one situation. This process is performed for each situation. We used Q learning algorithm [21] to form parameter weights. Each generated facial expression is related to a state in the learning process. The reward is calculated by a function of the predicted grade for current facial expression and the actual grade. If the predicted and the taken grades are consistent, the reward for the action will be high. The learning process updates the Q values of the states at each step. After determining parameter weights (when the convergence criteria is ensured), the clustering algorithm runs softly. The optimum number of clusters are formed by using these weight values and the optimum number criteria.

Parameter weights are used in distance calculation among inter-clusters, and between cluster centers and the data samples in the clustering process. As a result, some parameters may have no effect on a facial expression. In

this case they have zero weight. Therefore dimension reduction is carried out to indicate the importance of the features according to the effects on the facial expressions. After determining the parameter weights, the clustering procedure starts with a certain number of user information. By coming of new information about new users, clustering procedure continues dynamically. Cluster representation is ensured by showing cluster centers and the important cluster samples in a cycle of a simulation as a facial animation. Thus the cluster representation problem is surpassed.

Clustering of data is determining natural groupings in data or labeling unlabeled data in which similar ones are grouped. Clustering process is very convenient to determine society profile. There are many clustering algorithms, but there is no standard algorithm for all kind of data. Different hierarchical and partitional algorithms serve for different types of data for clustering. The details of clustering algorithms can be found in [22]. The k -means is a partitional algorithm using squared error criteria. It is an iterative algorithm for a given cluster number. The k -means clusters data samples so that the similar samples are in the same cluster, and the clusters are as different from each other as possible. We have chosen the fuzzy c -means (FCM, fuzzy type of the k -means) algorithm for our system. In this algorithm, data samples are assigned to the clusters by membership values. Therefore the membership values of data samples are ranged between [0,1].

The number of clusters in the k -means is determined before the algorithm runs. We used partition coefficient criteria [23] to determine the most efficient cluster number. By using this criteria, the membership values of data samples are considered, then the cluster number which maximizes the sum of membership values of the data samples is determined.

4. CONCLUSION

Our system produces a society profile and agent beliefs by intelligent agents. The system components are implemented and tested. We implemented the FCM on simulation data. We are also testing some hybrid methods. The difficulty with the work is that there are no real or simulation test sets for facial expressions. The reason for using distributed data in the learning process is to model all of the society and to request small number of criticisms from each user for determining parameter weights. The simulation of all the grades generated by a small group causes this facility be non-effective because many trials are needed. If we choose grade values randomly, there will not be meaningful results. However, a pedagogical expertise was not used to get efficient results in the implementation.

The system should be tested on the real world (e.g. on the students in a primary school). This work requires an interdisciplinary team. We are working on an effective question set. The questions asked to users can be modified

adaptively according to the groups of users having similar profiles. Users may be allowed to grade questions to form an effective question set. The graphical interface should be more friendly. Different face textures may be used for groups of different ages or sexuality. Then the results can be used for pedagogical experiments. The system may be used to diagnosis of some disabilities with the help of the other social tests prepared by pedagogues.

The specific user groups or societies may be formed to consider their data separately. Therefore by determining the group of a user, the facial expressions of this society profile may be downloaded, and there would be no need to run all of the processes again for this user. To implement this kind of service, a federated and distributed agent system may be formed. There may be needed to multiply the number of Routers in the system to represent different societies. The societies may be formed by using information about sexuality, age, nation, etc. Therefore differences among groups may be determined. Although grouping process reduces computational and storage requirements, a huge data set should be considered.

Facial muscle objects may be modeled as intelligent agents to form facial expression. All of the muscle objects are reactive, and they communicate with UIA through different ports in the original implementation. Different parts of the same face may live on different hosts and may be controllable by different users.

In a supplementary work, an effective inference algorithm may provide signals for muscle actuators for different facial expressions in different cases. By using additional components, such as syntax and semantic extraction, the system may produce different facial expressions for given statements.

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