MAGPIE:Pervasive Environment with Emotional Awareness for Managing Information in the Context of Collaborative Communities

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***Abstract*—MAGPIE is a pervasive environment that supports communities to collaborate and share contents relevant to their interests. We focus on the integration of the emotional response of the user in order to suggest contents that are relevant to the current context. The main contribution of this work is to propose architecture for pervasive environments that integrates content adaptation to user emotional state, profile and interests with ambient intelligence and device adaptation.**

Keywords: Emotional Awareness, Pervasive Environments, User adaptation, context awareness

I. Introduction

A collaborative community is a group of people that share a common interest and a common goal. Through many interactions and activities the community constructs collective knowledge over time around their topics of concern represented in a collection of contents which can be as varied as those in the web 2.0 sphere: images, video, blog posts, articles, news, etc. Also, as in the web, these communities maintain a high volume of information that is difficult to manage. Mark Weiser said in [*1*]: “ubiquitous computing will help overcome information overload” and “create a calmer environment” by embedding computation in everyday objects. This is why we believe communities would benefit from a pervasive environment and because they are meant to “enable opportunistic collaboration, facilitate social interaction and support teaching and learning” [*2*], common activities for them.

MAGPIE (MAnaGing Pervasive Information Environments) is a pervasive environment designed for this type of communities. In this stage of research, the main concern is to focus on the users’ affective states. Emotions play important roles in social interactions and human cognition [*3*] so an emotional aware environment will enhance the user experience and help to better achieve the community’s goal. Moreover, affective state can be used as input of the degree of interest of the user in the current topic of discussion or the current documents in which users are working on. MAGPIE aims to deliver content that is relevant, interesting and increases the positive emotions on the participants.

To achieve this goal, MAGPIE adapts itself to the user, context, activity and the affective state of the participants by recognizing posture and facial gesture. Additionally, MAGPIE performs common tasks of information management in order to be able to suggest contents to each participant. The main contribution of this work is to propose an architecture for pervasive environments that combines the elements of ambient intelligence, user and context awareness, content management and community support.

This paper is organized into 6 sections: Section 2 describes related work in pervasive environments, emotional awareness and context-aware content fields and a comparison with our work. In section 3 we present MAGPIE, its main objectives and design considerations. Section 4 outlines the proposed architecture and ongoing work and lastly, we conclude and discuss future work.

II. Related Work

This section presents theoretical background and previous work in the fields that constitute the main concerns for MAGPIE: emotional awareness, pervasive environments with ambient intelligence and content management with a focus on academic content and context-aware content.

Psychologists have researched emotion for a long time. There are different emotional models, being the one proposed by Ekman in [*4*] one of the most popular. However, the emotions described there deal more with social interactions than with cognition itself. The proposed emotional model in [*5*] deals with emotions of learners which are more appropriate for an academic collaborative community. These emotional states are: frustration, boredom, eureka or the feeling of discovery and understanding, confusion, anger, interest and curiosity. For an emotional aware system to be able to recognize human emotion, it must learn to classify the corporal signs that represent each emotion. There is a great variety methods for characterizing emotions based on physical characteristics such as facial expression, speech and posture or in physiological characteristics such as heart beat, sweating, pupil dilatation, etc. Most of these methods are described in [*6*]. We are focusing on interpretation of corporal language, that is, facial expression and posture. Ekman [*7*], Coulson [*8*], Pasch [*9*] and Günther [*10*] show how facial expression and posture can be used to recognize emotion. Baltrusaitis et al. show how emotion recognition can be achieved by the analysis of facial gesture and body posture using Hidden Markov Models and Dynamic Bayesian Networks. [*11*] They recognize the six basic emotions proposed by Ekman, whereas MagPie is intended to recognize other emotions.

In the field of pervasive environments, there are several proposals to design them. CASMAS [*12*] proposes a model to support collaboration in a changing community through the sharing of information. It manages the community with a set of rules that can change according to participation and context. CASMAS does not take into account the emotions that might impact collaboration and participation. It doesn't either manage contents or the information the community has available, only things that are happening inside the room. The work by Lino [*13*] summarizes aspects of what a pervasive environment (called responsive environment) should provide to the user. They insist in the importance of a user centric experience and provide a classification of how the environment responds depending on how much it adapts to the user. Most of the examples given provide entertaining experiences for the user. In contrast, MAGPIE proposes an environment that helps the user interact with the contents stored to achieve a goal. We also propose adding emotional awareness to the environment in order to make it a perceptive environment that adapts its responses (content suggestion) according to the implicit input given by emotional response and the explicit input given by the user.

Finally, content management and information retrieval are becoming increasingly important nowadays to overcome the problem of information overload [*14*]. Given the large amount of contents that an academic community manages, MAGPIE is initially directed to these communities, without leaving outside other types of communities in its design. Academic content management is important as researchers need to organize and keep track of the references they use. There are many different tools available such as Mendeley [*15*], Qiqqa [*16*], Google Books [*17*], Google Scholar [*18*], Youtube's university and research channels [*19*] and others. Google Scholar and Google Books are Google's search engine for finding academic publications and books ranked by relevance, author, publication's index and other important features for researchers. Just as other Google products, Google Books and Google Scholar show contents that are similar to those that the user found relevant in the past (by clicking them). However, it is not context aware so it can show me results that are no longer interesting to me or that are not relevant for my current activity. They aren't emotional aware either, so if I'm frustrated with search results and not finding what I want, they might keep showing me the same results and increase my frustration. Youtube's channels have a similar approach since Youtube makes personalized recommendations based on videos seen lately. They also let users subscribe to channels to get the latest uploads. This has the same problem stated above: since it is not context aware, I can get recommendations that are not relevant to my current activity. Mendeley is a social reference management tool as it lets users participate in groups and join their colleagues to find relevant content to their research areas. It also provides users with a personal library so they can store their documents. It suggests publications to users by collaborative-filtering.

Finally, Qiqqa lets users create libraries and share them with other users so they can collaborate and share documents. Qiqqa suggests contents based on authors, topics and keywords of recently read articles.

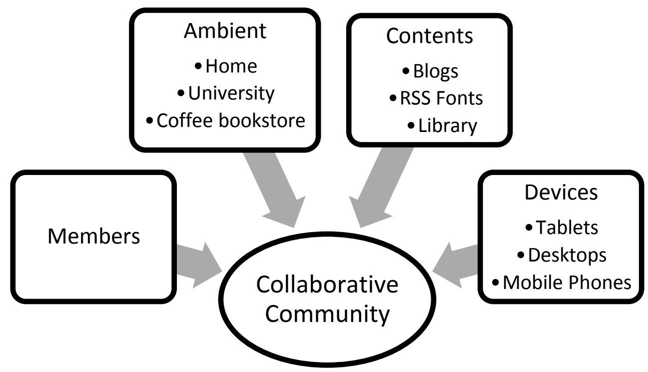

Figure 1: Context of a Collaborative Community

Neither Qiqqa nor Mendeley support real time collaboration or content suggestion based on the current research, just the overall profile. They are neither context aware nor emotional aware just as the Google products.

In summary, there is a strong background in each major driver of MAGPIE but there isn't a proposal that combines them all to provide a better user experience and more relevant content suggestions. Neji, Ben Ammar and Alimi combine Information Retrieval with the analysis of emotional state but in the context of a tutor, which has a curriculum that pre-selects contents and the sequence in which they should be given to the user [*20*].

III. MAGPIE

A. Approach

MAGPIE has two main objectives. The first one is to support collaboration through content sharing and discussion in a collaborative community. The second one is to provide users with relevant content by adapting search results to context and emotions and making suggestions based also on related colleagues' relevant content or suggestions (collaborative filtering). In this stage of research, we focus on academic communities because is a community we know from the inside. As shown in figure 1, in a collaborative community, members, contents from various sources, different devices and the ambient where members work together, interact in the daily life of collaborative communities. For this reason, MAGPIE brings together ambient intelligence, device adaptation and context, user and emotional awareness to create a pervasive environment that helps users interact with each other and collaborate both face to face and in asynchronous ways.

In the current state of the work, focus in on emotion recognition and responsiveness since emotions have been proved to have an impact in social interactions, participation, creativity and learning [*3*] all of which affect a community that needs to collaborate to achieve its goals. Emotion recognition is used for two purposes: as an implicit input on how much the user liked or didn't like the current content and as an aid for content suggestion. This means MAGPIE suggests content according to the user interests and based on his/her emotional response to those suggestion adapts subsequent suggestions. The emotional states MAGPIE recognizes are a subset of those mentioned in Autotutor (5): frustration (see figure 2), interest (see figure 3), boredom (see figure 4), confusion (see figure 5), and curiosity (see figure 6).

Figure 2: Frustration [*21*]

Figure 3: Interest [*22*]

Figure 4: Boredom [*23*]

Content management is the second driver addressed in this work. It is especially important because contents represent the collective knowledge built and obtained by the community. Content management has been previously addressed by the authors in Mental Watch [*24*] and a great part of the work is being reused for MAGPIE.

B. Functional Description

As stated before, MAGPIE is a content management environment that adapts search results and suggestions to user's context and emotions. In addition to searching and finding content through automatic suggestions, users can share contents they find relevant by suggesting them to another user or a whole project or topic. While reading a document, users can comment and rate it for a particular project or research topic. Ratings help MAGPIE do better suggestions. By sharing comments, users can discuss contents and topics. By suggesting contents to other users and participating in discussions, users collaborate to the community. When users meet in MAGPIE, they can see what each other is reading and commenting.

Figure 5: Confusion [*25*]

Figure 6: Curiosity [*26*]

C. *MAGPIE at work*

To illustrate how MAGPIE works we present a typical situation in a research community. In research communities members participate in projects that follow a research topic of the community. To each project and research topic there is a set of contents produced by the community and another set of contents that gather work by other communities in the same topic. Let's say two members of the community are currently working at project P and they meet to discuss current state and work on it. Any interaction between members of the community is called a session, so we say user A and user B are in a session. They have researched and gathered papers by international communities and they are also reading previous work of their community. User A is reading the paper at her tablet and user B is using his notebook. User A is very engaged in the discussion and finds it interesting so she smiles, nods and leans towards her tablet constantly. On the other hand, user B is confused about the topic of the paper being discussed; he frowns and touches his forehead constantly. MAGPIE senses this affective states and suggests user B a paper explaining in more detail what the topic is which has been archived by the community a long time ago while suggesting user A a recent blog post by a community member discussing new ideas to add to the project.

IV. ARCHITECTURE AND IMPLEMENTATION

In this section we describe the proposed architecture for MAGPIE, which constitutes the main contribution of this paper.

We have identified three major components for MAGPIE: `ContentManagement`, `CommunityManagement` and `SessionManagement`. These three components do not only have different responsibilities and requirements, but also different design considerations and thus, differently built and with different choice of technology.

A. *Content Management*

The `ContentManagement` component (figure 7), as its name suggests, it is responsible for managing the content that is relevant to the community. This component visits sources identified by the community to obtain contents and index and store them at the content repository. It also provides semantic search capabilities of this content and provides visualization services. The architecture of this component is very similar to that of Mental Watch [*24*]. It has 9 components: visualization, search controller, content repository, indexing controller, similarity analyzer, metadata extraction, semantic enrichment, sources and crawler. The differences are evidenced mostly in the internals of the components. For example, the semantic enricher in MentalWatch uses a taxonomy of diseases which is of no use for the current project. Instead we use taxonomy of topics and investigation lines. We also added a similarity analyzer to identify repeated content.

The sources component manages the URL of the different sources relevant to the community that are then crawled by the crawling component to obtain the contents published there. The contents are then passed to the indexing controller which uses the metadata extraction component to extract metadata like keywords, author, publisher and title and generates a vector document of each new document. Using the similarity analyzer, the indexing controller analyzes if the content is already in the repository. If it isn't, it is stored in the content repository with all related metadata, which is a No-SQL repository because it manages non-structured data. The search controller provides services for searching contents. It uses the semantic enrichment to expand user queries. This component is the same as in MentalWatch. The visualization component provides services for visualizing the contents in different devices and in different contexts. For another type of community, the metadata extraction component would have to change to identify relevant metadata for the community.

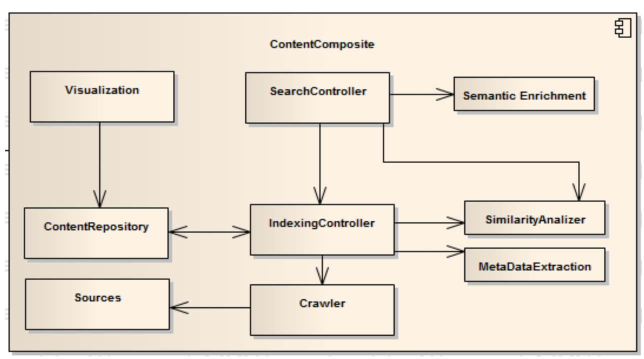

Figure 7: Content Management Functional View

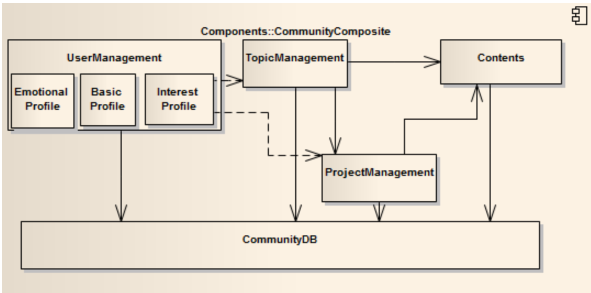

Figure 8: Community Management Functional View

B. *Community Management*

The `CommunityManagement` (figure 8) manages all the information about the community: members, projects and research topics. Information about members includes three user profiles: emotional profile, which is based on the five factor personality model; interest and expertise profile, which is a numeric rating of the degree of interest, and expertise the user has in research topics and projects and a basic user profile which has personal information about the user and his role in the community. The emotional profile is obtained once with a questionnaire and gives a numeric rating to each one of the following factors: openness, conscientiousness, extraversion, agreeableness, and neuroticism. The interest profile is constructed continuously with user explicit input about a content, source or topic or implicit input based on emotional response to the content. Information about projects includes the topics covered by it, members of the community participating, name, date started and if it is already finished or in course.

This component also manages references to the contents saved in the content management component to save a rating of content relevance for each topic or project. This rating is provided by users as they consult the contents and is used for content suggestion for each topic. There is also a 'document tray' for each user where suggested content or content marked as 'read it later' is stored for future reference.

This component is designed as a two tier application: persistence and business layer. It is implemented using MySql and JEE.

Both the topic and project components would change in a different community to represent what the community interests and activities are.

C. *Session Management*

The session component monitors session activity and context and responds to them. It has 5 main components: emotional awareness, activity recognition, ambient intelligence, suggestion engine and ambient conditions engine. The emotional awareness component has a three tier architecture: `Sensing`, `FeatureExtraction` and `EmotionIdentification`. The component senses users' postures and facial gestures and interprets them according to the user emotional profile to classify them in one of the emotions described in section 3. We have decided to use a Kinect® device to detect postures, thus, a posture is a combination of the different position (x,y,z) and rotation (expressed in quaternions) of the upper body joints detected by this device(head, neck, collar, shoulders, elbows, wrists, hands, waist and torso). We are only using upper body joints since users will be mainly sitting. An emotional profile of the user based on the five factor personality model is used to have better accuracy since emotional expression depends highly on personality factors [*27*]. This emotional profile will be taken into account in future work. Emotion is classified using a naïveBayes classifier previously trained. For facial gesture we identify the following features based on the FACS described by Ekman and Friesen, an overview of which can be found in [*28*].

The activity recognition component detects a topic or project of discussion based on users in the session, their interests, projects they are involved in and the active contents of the session.It does so by monitoring active contents of all users (`contentMonitor`) and what interest they have (`interestMonitor`). Both the activity recognition component and the emotional awareness component write their results to the event register of the suggestion engine which takes this as an input with the user interest profile for making suggestions to each participant.

`AmbientIntelligence` component senses and interprets different ambient conditions such as lightning, noise, temperature, etc. It has an ambient condition engine that decides how to change these conditions based on the emotional states of the participants, the current conditions and the activity. For example, if the current activity is watching a video, this engine may decide to turn off the lights for a better projection. This component is not yet going to be implemented but it is included in the architecture design for future development.

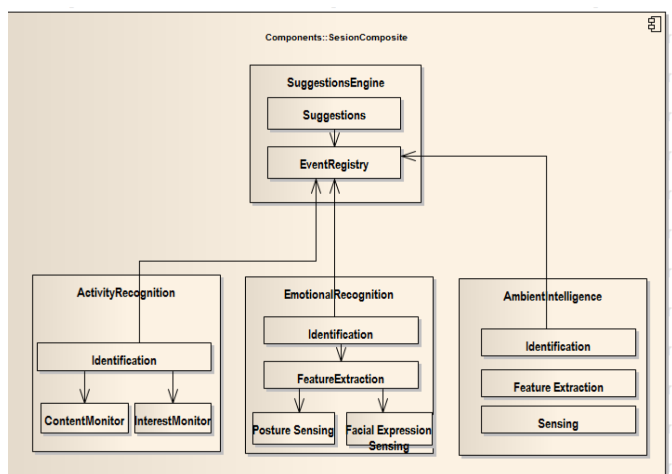

Figure 9: SessionManagement Component Functional View

D. Interaction between components

All three components provide services to interact with each other. When a user initiates a session, `SessionManagement` obtains his information from the `CommunityManagement` and his document tray. The user can search contents through `ContentManagement` and `ActivityRecognition` will start monitoring all the contents the user browses or searches for. When a topic or project is identified, the `SuggestionEngine` builds a query for `ContentManagement` and suggests the participant the contents obtained. These suggestions are sent to `CommunityManagement`. As the user reads a document he can rate it and this rating will be stored in `CommunityManagement`.

Interaction with the user is done through the user interface shown in figure 10. The user interface consumes services of the components to show the user an overview of what's happening in the session or to consult the different resources.

Figure 10: User Interface for Magpie

V. CURRENT STATE

At the present time, the emotion recognition module has been developed with real time emotion recognition based on facial expression. Facial features extraction is done with Luxand Face SDK [*29*], a library that provides 64 points around the face (figure 11). Based on the FACS described by Ekman, we selected a model of emotion based in distances between pairs of the points detected by Luxand Face SDK, which is intended to simulate these action units. The distances selected are shown in figure 12.

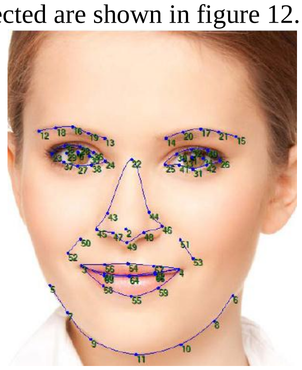

Figure 11: Facial Features detected by Luxand Face SDK.

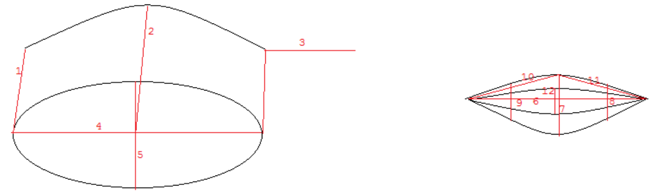

Figure 12: Distances model for facial expression. a): Distances in the eye b)Distances in the mouth

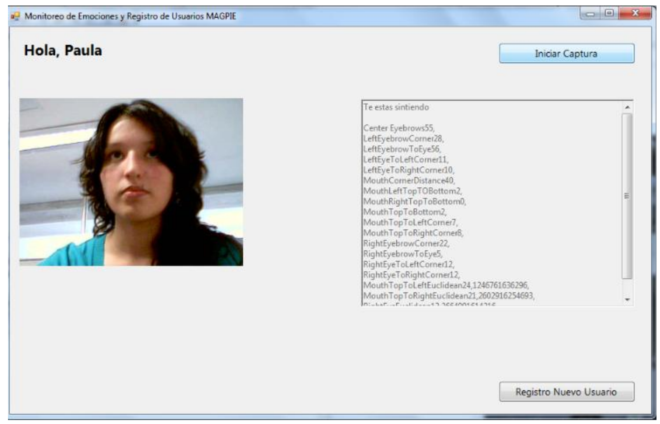

Figure 13: Module Extracting Facial Action Units

To test our model we created a training set with 600 data sets (100 for each emotion: neutral face, frustration, boredom, curiosity, interest and confusion) and a test data set of 300 instances for a single person since we are using a personal profile to recognize emotion. These data was collected by acting the expressions in order to get significant input for each emotion. We trained and tested different classifiers from the WEKA[1] framework and obtained the following results:

Classifier	Absolute Error	Correctly Classified Instances	Incorrectly Classified Instances
Neural Network	32,80%	242	58
Naive Bayes	54,22%	169	131
Rotation Forest	17,23%	300	0
Data Near Balanced	27,54%	255	45
Class Balanced	29,19%	257	43

Table 1: Results for different classifiers

[1] Available at http://www.cs.waikato.ac.nz/ml/weka/index.html

Based on the results obtained, we have decided to use a rotation forest classifier for the emotion recognition.

VI. CONCLUSIONS AND FUTURE WORK

In this work we presented the architecture for MAGPIE which is intended to serve as a first step towards a framework for designing emotional aware pervasive environments for collaborative communities. As an example, we use an academic community which has very stable characteristics, but more dynamic communities shouldn't be hard to manage as well with the proposed architecture.

Future challenges include adding ambient intelligence to the environments where sessions are held. Other challenge is to improve the emotional recognition by taking into account the emotional profile of the user and other signs of emotion expression such as speech. In content management adding an automatic classification into topics and projects based on past documents classified by the users would greatly improve the suggestion mechanism. We would like to also add better gestural interaction to the user interface.

VII. REFERENCES

[1] Mark Weiser, "The computer for the 21st century," *SIGMOBILE Mob. Comput. Commun. Rev.*, vol. 3, pp. 3-11, 1999.

[2] Roy Campbell, "Beyond Global Communications: The Active World," *Pervasive Computing and Communications, IEEE International Conference on*, vol. 0, p. 211, 2005.

[3] Antonio Damasio, *Descartes' Error – Emotion, reason and humanbrain*. London: Picador, 1994.

[4] P. Ekman, "Basic Emotions," in *Handbook of Cognition and Emotion*.: Wiley, 1999.

[5] S. D'Mello, A. Graesser, and R.W. Picard, "Toward an Affect-Sensitive AutoTutor," *Intelligent Systems, IEEE*, vol. 22, no. 4, pp. 53-61, 2007.

[6] Irene Lopatovska and Ioannis Arapakis, "Theories, methods and current research on emotions in library and information science, information retrieval and human-computer interaction," *Information Processing \& Management*, vol. In Press, Corrected Proof, pp. - , 2010.

[7] P. Ekman and W. V. Friesen, "Facial action coding system: a technique for the measurement of facial movement," 1978.

[8] Mark Coulson, "Attributing Emotion to Static Body Postures: Recognition Accuracy, Confusions, and Viewpoint Dependence," *Journal of Nonverbal Behavior*, vol. 28, pp. 117-139, 2004, 10.1023/B:JONB.0000023655.25550.be.

[9] Marco Pasch and Ronald Poppe, "Person or Puppet? The Role of Stimulus Realism in Attributing Emotion to Static Body Postures," , 2007, pp. 83-94.

[10] Rebel Günther, "Interpretación del Lenguaje Corporal," in *El lenguaje Corporal. Lo que expresan las actitudes, las posturas, los gestos y su interpretación*, 4th ed. Madrid: EDAF, S.L, 2009.

[11] T. Baltrusaitis et al., "Real-time inference of mental states from facial expressions and upper body gestures," , 2011, pp. 909-914.

[12] F. Cabitza, M.P. Locatelli, M. Sarini, and C. Simone, "CASMAS: supporting collaboration in pervasive environments," , 2006, pp. 10 pp. -295.

[13] Jorge Alves Lino, Benjamin Salem, and Matthias Rauterberg, "Responsive environments: User experiences for ambient intelligence," *J. Ambient Intell. Smart Environ.*, vol. 2, pp. 347-367, 2010.

[14] Jinwon Ho and Rong Tang, "Towards an optimal resolution to information overload: an infomediary approach," , 2001, pp. 91-96.

[15] Mendeley. [Online]. http://www.mendeley.com/

[16] Qiqqa. [Online]. http://www.qiqqa.com/

[17] Google Books. [Online]. http://books.google.com/

[18] Google Scholar. [Online]. http://scholar.google.com.co/

[19] Youtube Education. [Online]. http://www.youtube.com/edu

[20] M. Neji, M. Ben Ammar, and A.M. Alimi, "Real-time affective learner profile analysis using an EMASPEL framework," , 2011, pp. 664-670.

[21] [Online]. http://www.webdesign.org/web-design-basics/website-usability/the-cost-of-frustration.2395.html

[22] [Online]. http://www.ncpd.org/sites/default/files/u3/Interested%20Reader.JPG

[23] fantasiadvice.blogspot.com [Online]. http://fantasiadvice.blogspot.com/2007_12_01_archive.html

[24] D. Ramirez, P. Lago, D. Borda, and C. Jimenez-Guarin, "Mental health information Web search and semantic search extension," , 2011, pp. 1-6.

[25] [Online]. http://images.forbes.com/media/2010/11/18/1118_

confused-person_390x220.jpg

[26] [Online]. http://www.dreamstime.com/computer-curiosity-thumb15263105.jpg

[27] C. Clavel, A. Rilliard, T. Shochi, and J.-C. Martin, "Personality differences in the multimodal perception and expression of cultural attitudes and emotions," , 2009, pp. 1-6.

[28] FACS - Facial Action Coding System, 2011.

[29] Luxand. Face SDK. [Online]. http://www.luxand.com/facesdk/

[30] Günther Rebel, "Interpretación del Lenguaje Corporal," in *El lenguaje Corporal. Lo que expresan las actitudes, las posturas, los gestos y su interpretación*, 4th ed. Madrid: EDAF, S.L., 2009.

[31] Feed database. [Online]. http://cotesys.mmk.e-technik.tu-muenchen.de/isg/content/feed-database

[32] Audio-Visual Emotion Database in Persian Language. [Online]. http://emotion-research.net/Members/MuharramMansoorizadeh/audio-visual-emotion-database-in-persian-language-1

[33] Rml Emotion Database. [Online]. http://www.rml.ryerson.ca/rml-emotion-database.html

[34] FACS - Facial Action Coding System. [Online]. http://www.cs.cmu.edu/afs/cs/project/face/www/facs.htm