SOCIAL SENSOR DESIGN FOR EMBEDDED SYSTEMS

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Abstract: The socially-competent computing systems are intended to perform on two-levels of abstraction of the cognitively processed information – to define human behaviors, responding to other peoples’ behavior (basic level of system cognitive performance) and to define human behaviors, responding to other people’s attitudes (abstract level of system cognitive performance). The paper presents a model, capable of predicting behavior in response to attitudes for resource sharing in mobile communications. The applicability of the approach to other modalities of embeddedness via social sensor design is discussed.

Key words: socially-competent computing, embedded systems, social sensors

1. INTRODUCTION

Modern information systems for recording people and their interactions (e.g. surveillance systems, mobile communication networks) collect enormous amount of data which is being processed in a time and effort consuming way. Most of the approaches to social sensor design apply the analogy with pattern recognition theories or image processing methodology. The main indicators of the social nature of the object – the human – are the signifiers of social interaction and social signaling – voice intonation, hand gestures, flow of speech, posture, facial expression, etc. (Pentland, 2007). The main approach to modeling the nature of the interaction is based on collecting sets of features and classifying behavioral patterns, belonging to different social situations (Hernandes et al., 2010, Kim et al., 2010). Sequences of behaviors are modeled via Hidden Markov Models (Pan et al., 2010), Gaussian Mixture Models (Hernandes et al., 2010), Conditional Random Field (Kim et al., 2010) Laban movement theory (Lourens et al., 2010) and other machine learning approaches. Considering that, as physical objects, people are more flexible in
behavior and of changing appearances, it is not surprising that applying simply the developed techniques for object and pattern recognition in other domains is insufficient for diagnosing social presence in a situation. That is, current systems are capable of predicting behavior in response to behavior, based on modeling people as physical objects in dynamic interactions (i.e. physical level of modeling behavior). It is urgently needed to increase the ability of the systems to extract relevant features and to achieve better social competence, similar to the kind that is underlying human interactions.

If these systems are capable of predicting behavior in response to attitude, they can account for the social aspect, because this is what social sciences are about – understanding attitudes driving social behavior. In human society the third aspect of the interaction is predicting behavior in response to opinion (i.e. psychological level of modeling behavior). Present day information systems are far from modelling the third – psychological – aspect of the social interactions, which seems to be a very difficult research task. The main claim in the present paper is that the most important aspect is the social level of modelling interactions – predicting behaviour in response to attitude - for embedded system design. This will allow developing algorithms for predicting the outcomes of social interactions – whether conflict or consensus will result - from reading behavioural patterns in different modalities – visual (facial expressions, gestures), auditory (prosody), tactile (clash) etc.

2. SOCIAL COMPETENCE IN INFORMATION SYSTEMS

The socially-competent computing systems are therefore intended to perform on two-levels of abstraction of the cognitively processed information – to define human behaviors, responding to other peoples’ behavior (basic level of system cognitive performance) and to define human behaviors, responding to other people’s attitudes (abstract level of system cognitive performance). Whereas most effort is directed towards implementing intelligent systems, performing reliably on the basic level, embedded systems can achieve more flexible performance if they are capable of defining behaviors, responding to other people’s attitudes. To achieve this goal in design of socially aware computing, the application of personality theories – complementarily to social network theoretical approaches – is proposed. The personality theory of D.C. Funder is employed in the present context (Funder, 2006).

According to D.C. Funder, personality-dependent behaviors are orthogonal to situation-induced behaviors. Situations may demand particular kinds of behavior and these can also be graded in terms of dynamics and intensity. Along this gradation of the situation demand, however, people preserve style of response to the demand. That is, generous people will preserve generosity across situations, which is independent (i.e. orthogonal) personality future in respect to the way people take risks, for example.
In figure 1 a dimension called selfishness-generosity (SG) is shown, where the quality is assessed by its distribution in the human population. The assumption is made that most of the people are characterized by modest degrees of selfishness or generosity, whereas the extremes are less frequent thus obeying the normal distribution law.

![Figure 1. Distribution of a personality feature in the human population (e.g. selfishness-generosity)](image1)

Personality is being defined by multiple dimensions forming multi-dimensional array of qualities, captured by the respective social sensors. We are currently modeling personality along 2 dimensions – level of generosity, characteristic for a person – and level of risk-taking, characteristic for the person (figure 2).

![Figure 2. Personality dimensions for embedded systems](image2)

According to the above presented theory personalities emit behaviors, whereas situations elicit behaviors (Funder, 2006). An external view on a particular behavior may not distinguish whether it has been elicited by the situation, or emitted by the personality. The internal view is based on the person’ own decision whether to emit behavior or allow the situation elicit it, or at least, be aware on the circumstances, relations or emotions inducing their personal behaviors.
Two application scenarios are investigated. The first one is generosity in sharing resource in mobile communications. The second is risk taking in medical interventions. These are intended for emergency situations for adequate task allocation of the rescue team.

The generosity feature in sharing resource in mobile communications is proposed in (Dimitrova et al., 2010). The risk-taking dimension is currently being modeled. There is infinite number of features, possible to be modeled in embedded systems. The important is the need to choose features that are orthogonal in order to avoid redundant calculations and achieve adequate construct validity.

Two application scenarios are presented in the next section:
1) Social sensor design for mobile Ad hoc networks;
2) Social sensor design in embedded systems for medical interventions.

The framework is oriented towards development of socially competent robotics (Sharkey, 2008), (Barakova and Vanderelst, 2011), (Barakova, and Lourens, 2010) and smart environments (Deleawe et al., 2010).

2.1. Social sensor design for mobile Ad hoc networks

One of the problems in mobile Ad hoc networks (MANETs) is dealing with the so called “selfish node” behavior – i.e. “selfish nodes refuse to help other nodes in forwarding packets due to the anxiety of having resource degradation such as exhausted battery power and limited processor capacity” (Razak et al., 2009, p.440).

The aim of the present work is to propose optimization algorithm for packet transmission in mobile ad-hoc networks (MANETs) via multi-hop communication. The efficient packet transmission in MANETs has to deal with specific communication constraints: 1) device resources (power, bandwidth, CPU); 2) user resources – subscription plan, network coverage and personal contacts.

The detrimental factors for network efficient performance are: 1) Number of selfish nodes in a network which, if greater than 20%, lead to drastic drop in the network performance; 2) Node hostility which refers to node dropping packets without forwarding them; 3) Node maliciousness which is a node making another arbitrary node look selfish; 4) Node cheating that is a node “pretending” to be active while probed for selfishness until end of probe and becoming hostile after that.

A Generosity model for resource allocation in MANETs, based on the Personality theory account of D.C. Funder (Funder, 2006) is currently implemented. The inspiration for the proposed framework comes from the following situation. Imagine a group of teenagers in the park - the way they use their mobile phones to call friends is resource sparing. Therefore, mobile phone technology is shared communication resource for the group rather than an individual accessory. In everyday situations resources are shared on the basis of friendships, whereas in emergency – depending on the individual will to provide personal resource to someone in need i.e. thanks to their generosity. As any human personality feature –
generosity/selfishness can be within some reasonable boundaries, or else – outside these boundaries in unreasonable or extreme degree of manifestation.

Four main variables of the proposed framework are outlined:
- Situation demand;
- Usefulness of sharing resource;
- Degree of node generosity;
- Prediction of future node generosity value.

These variables are defined via the respective membership functions $\mu_s$, $\mu_u$, $\mu_g$ and $\mu_p$. The proposed personality filter involves formulation of negotiation strategies related to styles of behavior determined by the personality and the situation demand. The degree of generosity whenever resources are to be shared will depend on negotiation and will be proportionate to the expected usefulness of the endowed resource. We account for 2 kinds/degrees of generosity and the respective selfishness of nodes in mobile networks under communication constraints – reasonable/unreasonable degrees of node generosity/selfishness.

Three optimization cases are considered. The first one is so called Ad hoc optimization (figure 3).

![Ad hoc optimization](image)

**Fig. 3. Ad hoc optimization**

Within the presented above framework the activity probing node tries to diagnose the neighboring nodes as hostile, malicious or cheating (Kargl et al., 2005), (Razak et al., 2009). It is evident from figure 3 that this type of optimization is resource consuming and inefficient. The battery may be exhausted before packet forwarding can actually take place.

The second type of optimization is based on the much popular today social network theory approach (e.g. Bottazzi et al., 2007). Within this approach the connectivity analyzing node performs large amount of computation; it requires full connectivity data and may suffer from the circularity problem (figure 4).
The third approach implements a personality filter, accounting for both cases when the relative degree of the neighboring generosity/selfishness can be determined (figure 5).

The activity probing node reads the relative amount of resource of the neighboring nodes (Ra) and the recent history of communication (Rc). Based on a simple formula, the degrees of generosity/selfishness of the nearest nodes are determined. Simulations are carried out in Gephi and MatLab. The results show that the main advantage is in the need to assess the amount of resource of a node relative only to the neighboring nodes by incremental probing.

The main specificity of the approach is the distinction between situation (in general) and situation demand (externalized assessment of the appropriateness of some behavioral act). Once the situation demand is determined, the observed...
behavior can be assessed as conforming or not to this demand. The modeled situation demands are of 2 kinds – urgent packet forwarding of small size vs. large packet forwarding. Fast negotiation strategies are preferred within the negotiation area of reasonable selfishness/generosity whereas outside it – these have to be more elaborate. Within the reasonable range of selfishness/generosity, the important factor is that there is always spared some resource which can be shared in emergency situations, provided the relevant negotiation strategy is applied. Negotiation strategies for unreasonable selfishness/generosity involve more elaborate strategies for sharing resource. For example, cautious people often turn into unreservedly generous if it is pointed out to them the importance of their involvement in a good cause (unreasonably selfish node). The general personality theory based assumption is that within a socially significant context nodes will assess the situation demand and will respond appropriately in rescue situations by sharing resource or personal contacts.

2.2. Social sensor design in embedded systems for task allocation in rescue operations

Current work involves a framework for task allocation of the rescue team in emergency situations. It is known that there are situations demanding risk-taking behavior, on the one hand, and risk-avoiding (cautious) behavior, on the other. In monitoring of the destabilizing factors of the environment for emergency operations, human actions can be recorded in respect to cautiousness or risk taking adequate to the situation demand (Ossikovska et al., 2009). The main variables are similar to the used above:

• Situation demand;
• Usefulness of taking risk;
• Degree of activity in risky situations;
• Prediction of future risk taking value.

The main parameter for determining the risk taking as personality feature is the index of correct actions in unpredictable environments as opposed to the number of correct actions when the parameters of the environment are constant. The Fukushima crisis is a recent example of the emerging need to also develop similar socially-competent embedded systems for rescue operations and implement them in smart environments.

3. CONCLUSION

A framework is proposed for dynamically determining degrees of manifestation of personality dimensions for various situation demands. It implements characteristic features of personalities in relative terms and employs fuzzy system representation. The main contribution of the present work is in defining new statistical indicators of social variables. The proposed social sensors for embedded systems are capable of
deriving conclusions about *attitudes* that underlie behaviors and not just providing interpretation of the observed behaviors. Future work includes tests and validation of the proposed framework in realistic situations. The presented research is oriented towards embedded systems for socially competent robotics in smart environments.

**REFERENCES**


