COMMUNICATION IN CRISIS SITUATIONS USING ICON LANGUAGE*

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ABSTRACT

To reduce the ambiguity and the different semantic interpretation of human observers' reports, we propose a new paradigm in collaborating information using icons to represent concepts or ideas. Two prototypes of icon-based communication interfaces were developed with which users can create iconic messages to report situations where a crisis event occurs. The interfaces interpret and convert the messages to human natural language. A context-aware collaborative information system filters irrelevant and infidelity reports and shares the results for further decision making.

1. INTRODUCTION

In crisis events, such as natural disasters, technology failures, aviation accidents, or acts of terrorism, a global infrastructure breakdown is inevitable. In such situations personal devices, such as Personal Digital Assistants (PDAs), may become available alternative for communicating to others due to their portability and facility for wireless connection. However, a PDA provides limited options of user interactions, i.e. with a pointing device on its display, some physical buttons and (for some PDAs) a small-sized keyboard. Although researches have been done on adding multimodal capabilities e.g. [5][6][13], the current technology still make speech input less suitable for mobility [2]. Therefore, we aimed at a natural interaction style based on a GUI.

Reports form all parties involved in a crisis event, such as rescue teams, victims, witnesses and families, are essential to have a clear description of a situation for effective problem solving and preventing further damages. However, human observers reports tend to be subjective, ambiguous, incomplete and language dependent. Moreover, the human observers are usually remote in time and place. By limiting the world model using the same ontology, we can reduce the subjective aspect of reports only focused on relevant descriptions of situations that relates to the crisis event. To encounter a short term memory lost, the report should be sent as direct as possible. By collaborating all received information can then filter only unambiguous and complete information. Finally, to avoid creating language problems, we should choose a representation that offers a potential across language barriers. Icons and other concepts from semiotics are selected for this type of representations [10].

Human communication involves the use of concepts. Concepts represent internal models of the human themselves, the outside world and of things with which they are interacting [10]. An icon is understood as a representation of a concept, i.e. object, action, or relation. By virtue of a resemblance between an icon and the object or the movement it stands for, the icon functions as communication means. Thereby, it offers a direct method of conversion to other modalities.

This paper describes two developed iconic interfaces on PDAs for crisis management. We investigated icons to represent concept or ideas. The use of the icon representation makes user interaction on both interfaces particularly suitable for a fast interaction in language-independent contexts.

2. LINGUA: SENDING ICONIC MESSAGES

Figure 1. The interface of Lingua

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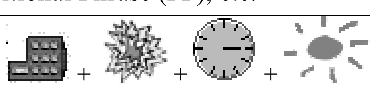
As a spatial arrangement of icons can form an iconic sentence [4], our first iconic interface was designed for reporting a situation using a string of icons on a PDA (figure 1). A user can select a sequence of icons as a realization of his/her observation of a crisis situation, i.e. accidents, explosions, fire, etc. The iconic interface is able to interpret the sequence and convert it into a human natural language text. The user can send it to a collaborative information system for further processing.

Via a telegraph or an SMS, we exchange information using concepts by composing important keywords. We can understand them because of our innate rules to determine possible shapes of language. In similar way, each icon that composes an iconic sentence also provides a portion of the semantic of a sentence (see figure 2 - input: "building" + "explosion" + "03.00" + "noon"). The meaning of an individual icon represents a word or a phrase created according to the metaphors appropriate for the context of the sentence. The meaning of the sentence is derived as a result of the combination of these icons and detected only from a global semantic of the sentence.

A workshop of 8 participants and a pilot has been conducted to acquire knowledge on formulating iconic message from sentences [7]. As comparison, large number corpora were also analyzed. Both studies had a similar result: each sentence was composed by a small number of icons that represent important keywords of the message. Based on these studies, we developed grammar rules using Backus Naur Form and English grammars (see examples on figure 2 – grammar rules). Each icon is grouped into categories, such as: nouns, pronouns, verbs, adjectives, etc, to define terminal symbols. For example: the icon "building" is categorized as a noun. The next step is to combine the icons into phrases as non-terminal symbols, such as: Sentence (S), Noun Phrase (NP), Prepositional Phrase (PP), etc.

Input: 

Grammar rules: NP ::= noun | noun NP
PP ::= preposition | preposition PP
S ::= NP PP

Slots:
- Prefix : (empty)
- Subject : article ("a") + noun ("building")
- Infix : to-be ("is")
- Verb : verb ("exploded")
- Object : (empty)
- Preposition : preposition ("at") + preposition ("15.00")
- Suffix : (empty)

Resulted text: "A building is exploded at 15.00"

Figure 2. An example of an input conversion

A parser checks an input against the grammars. If the input is syntactically correct, seven slots are crated: a prefix (for question words), subject, infix (for a to-be, an auxiliary and a negation), verb, object, preposition, and suffix slot (for a question mark, an exclamation mark, or an archaic word: "please"). The position of the slots depends on the type of a sentence, for example: for a questions sentence, the infix slot may be located between the prefix and the subject slot.

After transforming the input into the slots (see figure 2 - slots) and before displaying the resulted text, some extra rules are fired to complete the sentence. They specify conversion of an icon string into a natural language sentence based on the semantic context of the string. Some examples are rules for changing word's format, for adding an article, for adding a preposition, etc. We analyzed different formats of corpora to develop these rules.

3. ISME: ATTACHING ICONS TO MAPS

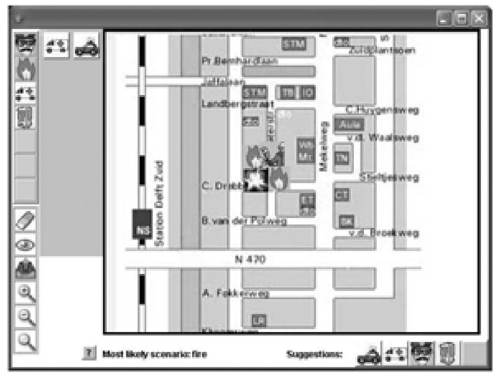


Figure 3. The interface of ISME

Some people are used to describe their observations by sketching on a piece of paper to support their verbal explanation. Bringing the idea to an iconic interface, we developed Icon-based System for Managing Emergencies (ISME) on a PDA (figure 3). A user can report about a crisis situation by placing icons on a map where the event occurs. The iconic interface creates a scenario that describes situations on the map and sends it to a collaborative information system for further processing.

The meaning of an individual icon in this interface also represents a word or a phrase. To provide extra information, each icon has some attributes. For example: the icon "explosion" has three attributes: status (under control, danger), size (small, big), and intensity (high, low). When a user places or manipulates an icon on a map, the interface creates new facts in XML scheme. The following is an example of facts created by a user:

```
<fact action="add" x="100" y="11" t="14:23:14">
    <icon group="people">fire fighter</icon>
    <attr id="status">wounded</attr>
</fact> …
```

The coordinate (x,y) of the icon on the map, in particular, is transformed into global coordinates.

To help a user to give an accurate and complete report, the interface provides: (1) menus for deleting an icon on a map, and for altering its attributes; (2) menus for zooming in and out, and moving a map. The zooming actions affect the map's size, not icons' size; and (3) a menu for displaying the current scenario based on the user's list of facts, which describes the user's world model. To create a scenario, an NLP module processes the list and converts it into natural language text using grammar rules on figure 4.

```
S    ::= preposition time NP PP
NP  ::= N* to-be ATTR1* | subject to-be AN ATTR2*
ATTR1* ::= attr-value | attr-value conjunct ATTR1*
ATTR2* ::= article attr-name to-be attr-value |
          article attr-name to-be attr-value conjunct ATTR2*
PP  ::= preposition street-name
N*  ::= article N
N    ::= people | building | vehicle
AN ::= article event
```

Figure 4. The grammar rules of ISME

The interface determines the "street-name" using a database that contains global coordinate of every street name. The following are examples of scenarios:

Around 14:23, a fire fighter is wounded on Steenstraat.

Around 14:23, there is a fire on Steenstraat; the status is danger and the size is big and the intensity is high …

4. CONTEXT-AWARE COLLABORATIVE INFORMATION

By means of both iconic interfaces and client server connections, users are able to communicate to a collaborative information system (CIS). Our proof of concept CIS performs dynamic adaptations whereas when a new report is subscribed, the world model will adapt it continuously. The CIS has a context awareness component to extract contextual information by measuring environmental variables, i.e. the selection on locations of objects in a user's environment or the user self's location at a time-range, to develop a crisis event world model.

The CIS collects all reports time-chronologically. A rule based approach is used to assign dynamic parameters, such as the priority and deadline for each event. A parser extracts every received report into logical expressions (L) that are constructed by atomic expression connected with logical operators. Each atom is a tuple t = (name_t, operator_t, value_t). An example of subscription (S) is:

S(L) = (building=1) AND (fire=1) AND
(time=15.00) AND (location = (99, 9))

Each atom will have a relevancy value – $r(L)$. This value will be increased if more observers report the same situation. A set of events e = (name_e, value_e), which e is member of E, defines the content of a crisis event at a certain location.

The next step is to measure context-aware environmental variable. If we use M different variables the state of the connection is defined in an M-dimensional context space – C. This space maps the M-dimensional state to a context value c, where c is member of X, a set of context classes. When a change in the environmental state is registered, the context of the previous subscription becomes invalid and has to be updated using equations:

$$L_p(c) = \{t \mid P(r(t), c) \geq p\}$$

$$s_p(c) = S(L^p_{sub}(c))$$

where P is a priority matrix to assign the priority p to each atom in L and s is the subset of atoms. Atoms that are used in the subscription with a higher priority are also used in the subscriptions with a lower priority, so the later is less restrictive: $s_{p=HIGH}(c) \leq s_{p=LOW}(c)$

The report selection algorithm filters reports based on their prioritized subscriptions and the contents of events. First, it matches all atoms with the notification of events, using the following equation:

$$MATCH(t,e) = \begin{cases} true \Leftrightarrow name_e = name_t \cap operator_t(value_e, value_t) \\ false, otherwise \end{cases}$$

Next, the algorithm checks if the logical expression of S to the atoms of the prioritized subscription $s_p(c)$ results true:

$$Evaluate\ (s_p(c)) = \begin{cases} p, if\ \_\ s_p(c) = true \\ null\ , else \end{cases}$$

$s_p(c)$ is true means the received report is accepted with priority p. A set of accepted $s_p(c)$, which is member of E_e, will be shared to a decision making module in the crisis management service.

5. DESIGN USABLE ICONIC INTERFACE

To avoid poorly designed icons, we used some guidelines and standards for designing an icon, e.g. [8][9]. We also used semiotics approach [3] to design and evaluate our icons. This approach relates with how close the interpretation in a user's mind is to what the icon represents [11]. For each icon, we performed a user test in the context of other icons based on the equations [8]:

$\text{Icon}_i + \text{Context}_j + \text{Viewer}_k ::= \text{Meaning}_{ijk}$

To encounter problems of linguistics and culturally bias of the interpretation of an icon, we selected test participants from different nationalities.

Our design concept provides navigation around icons for users by four ways: (1) grouping related icons in the same concepts to hint where an icon can be found [8]; (2) providing a distinctive appearance of a selected icon from the rest unselected icons; (3) Lingua, in particular, provides a real-time distinctive appearance of which icons can be selected according to syntactical rules; and (4) providing an icon prediction. We adapted an n-gram word prediction technique [12], which estimates the probability of an icon string s using Bayes rule:

$$P(s) = P(w_1, w_2, ..., w_n) = \prod_{i=1}^{n} P(w_i \mid w_i, ..., w_{i-1}) = \prod_{i=1}^{n} P(w_i \mid h_i)$$

where h_i is the relevant history when predicting w_i (icon$_i$). It operates by generating a list of next possible icons. A user either chooses one of the suggestions or continues entering icons until the intended arrangement appears. Our developed icon prediction collects the data from user selections. Besides to prevent error and improving the input speed, by these four features, the interface offers an opportunity to mobile users who cannot devote their full attention to operate the application.

6. EXPERIMENT EVALUATION

A user test was performed to assess whether users are capable to describe situations solely using a spatial arrangement of icons. This test also addressed usability issues of both interfaces. 8 people and a pilot from different nationalities took part in the test. We run the experiment using the "Thinking Aloud method" [1]. Each participant had 6 tasks. The first 3 tasks were created using cartoon-like stories that described a crisis event. A participant used Lingua to report them. In the last 3 tasks, we showed participants a map of a crisis event (e.g. car accident). The participants used ISME to report situations that were observed by placing icons on the map.

All activities were recorded on a tape and all user interactions were logged. From the results it appeared that our target users were able to express their concepts and ideas in mind using icons on both interfaces. The results also indicted that the users still had problems in finding their desired icons. The reasons were referring to: (1) adaptation time; (2) the cognitive process to find more relevant concept to represent messages; and (3) due to limited provided icons, which made the user should have rethought another concept that could fit with the problem.

7. CONCLUSION

Two experimental icon-based communication interfaces have been developed. The first prototype is an interface for creating and sending observation reports using icon strings. The second is an interface for describing situations on a map, where a crisis event occurs. Both interfaces limit the world model of observers by providing only icons that are relevant for crisis situations. However, we still found the users wanted to generate some icon strings, which were out of domain. Future work is necessary to analyze more corpora and icons that are relevant for crisis situations.

Our context awareness collaborative information system provides dynamic environment status of a crisis event. Using a rule based approach, it selects only relevant, fidelity and within timeline repots and shares them to a decision making module.

Our experimental results showed that both iconic interfaces could serve as communication mediator. Nevertheless, besides to cover more user and usability requirements in mobile context use, a field test is still necessary to gather data about how people use and experience an iconic interface in a real life crisis situation during mobile, to measure the complexity of the icon language and the information richness compared to natural language. A long run evaluation is also valuable to analyze the scalability of the representation and the impact of learning process on user interactions with this type of interfaces.

11. REFERENCES

[1] Boren T. & Ramey J., Thinking Aloud: Reconciling Theory and Practice, IEEE Transactions on Professional Communication, 2000.

[2] Bousquet-Vernhettes C., Privat R., & Vigouroux N., Error Handing in Spoken Dialogue Systems: Toward Corrective Dialogue, *Proc. of ISCA'03*, USA, 2003.

[3] Chandler D., Semiotics: the Basic, Routledge, 2001.

[4] Chang S. K., Polese G., Orefice S., & Tucci M., A Methodology and Interactive Environment for Iconic language Design, *International Journal of Human Computer Studies*, 1994.

[5] Cameford L., Frank D., Gopalakrishnan P., Gopnanth R., & Sedivy J., The IBM Personal Assistant, *Proc. of. ICASSP'01*, USA, 2001.

[6] Dusan S., Gadbois G.J., & Flanagan J., Multimodal Interaction on PDA's Integrating Speech and Pen Inputs, *Proc. of EUROSPEECH'03*, Switzerland, 2003.

[7] Fitrianie S., An Icon-based Communication Tool on a PDA, Postgraduate Thesis, TU Eindhoven, 2004.

[8] Horton W., The Icon Book, New York, John Wiley, 1994.

[9] ISO/IEC, International Standard, Information Technology – User System Interfaces and Symbols – Icon Symbols and Functions, 1st Eds, ISO/IEC 11581-1 to 6, 2000.

[10] Perlovsky L.I., Emotions, Learning and Control, *Proc. of International Symposium: Intelligent Control, Intelligent Systems and Semiotics*, 131-137, 1999.

[11] Theleffsen T., Firstness and Thirdness Displacement: Epistemology of Pierce's Sign Trichotomies, AS/SA 10(2), Applied Semiotics, 2000.

[12] Wester M., User Evaluation of a Word Prediction System, Master's Thesis, Uppsala University, 2003.

[13] Wahlster W., Rethinger N., & Blocher A., SmartKom: Multimodal Communication with a Life-Like Character, *Proc. of EURSPEECH'01*, Denmark, 2001.