Communication in Crisis Situations using Icon Language*

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Abstract

To reduce the ambiguity and the different semantic interpretations 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

The terrorist strikes against U.S. targets on September 11, 2001 disabled the crisis management service that provides information support services for rescue teams (i.e. the fire-fighters, ambulance services, polices, the military, and other crisis management organizations), victims, witnesses and families. In crisis events, such as natural disasters, technology failures, aviation accidents, and acts of terrorism, a global infrastructure breakdown is inevitable. In such situations personal devices, such as Personal Digital Assistants (PDAs), may be available 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. [6][7][16], the current technology still makes speech input less suitable for mobility [3]. Therefore, we aimed at a natural interaction style based on a graphical user interface.

Reports from all parties involved in a crisis event, are essential to have a clear description of a situation for effective problem solving and preventing further damages. However, human-observer reports tend to be subjective, ambiguous, incomplete and language dependent. Moreover, the human observers are also usually remote in time and place. By limiting the world model of the observers using the same ontology, we can reduce the subjective aspect of reports. Therefore, observers can focus to report only a relevant description of situations that relates to the crisis event. To encounter a short term memory lost, human observers should be able to report the situation as direct as possible. By collaborating all received information, these reports can be filtered to have unambiguous and complete information. Finally, to avoid creating language problems, we should select a representation that offers a potential across language barriers. Icons and other concepts from semiotics are selected for this type of representations [11].

Human communication involves the use of concepts. Concepts represent internal models of the humans themselves, the outside world and of things with which they are interacting [11]. We investigated icons to represent concepts or ideas. 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. The use of icons to represent concepts or ideas 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 [5], 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 only 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 3 – the input). 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 cannot be detected without a global semantic of the sentence.

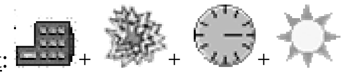
A workshop of 8 participants and a pilot has been conducted to acquire knowledge on formulating iconic messages from sentences [8]. As comparison, large number corpora were analyzed to have more insight. Both studies had a similar result: each sentence is composed by a small number of icons that represent important keywords of the message. Based on these studies, we developed grammar rules using Backus Naur Form and English grammars. Each icon is grouped into categories, such as: nouns, pronouns, proper-nouns, verbs, adjectives, adverbs, prepositions, and quantifiers, to define terminal symbols. For example from figure 3: 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. Figure 2 shows examples of grammar rules derived from the corpus on figure 3.

```
NP à  noun | noun NP
PP à  prepositional | prepositional PP
S à  NP PP
```

Figure 2. Examples of grammar rules of Lingua

A parser checks an input against the grammars. If the input is syntactically correct, seven slots are created: 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, e.g. "please"). The position of the slots depends on the type of a sentence, for example: for a question sentence, the infix slot may be located between the prefix and the subject slot.

After transforming the input into the slots (figure 3), some extra rules are fired to complete the sentence. They specify conversion of an iconic sentence into a natural language sentence based on the semantic context of the iconic sentence. Some examples are rules for changing word's format, for adding prepositional, question words, an auxiliary verb, a to-be, or an article, etc. To develop these rules, we analyzed corpora that included different format of sentences. For each input, the resulted text is displayed directly.

Input: 

Grammar rule: `NP à  noun | noun NP`
`PP à  prepositional | prepositional PP`
`S à  NP PP`

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

Resulted text : "A building is exploded at 15.00"

Figure 3. An Example of an input conversion

3. ISME: Attaching Icons to Maps

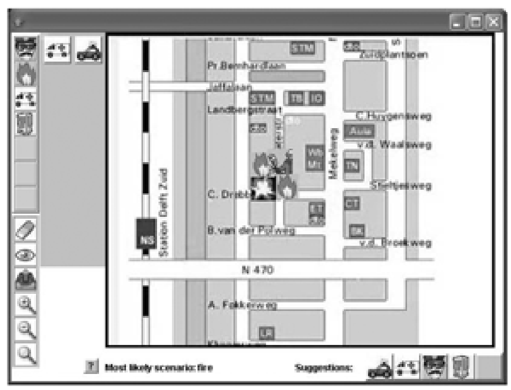


Figure 4. The interface of ISME

Some people are used to describe their observations by sketching on a piece of paper to support their verbal explanation. Bringing this idea to an iconic interface, we developed Icon-based System for Managing Emergencies (ISME) on a PDA (figure 4). 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 also has some attributes. For example: the icon "explosion" has three attributes: status (e.g. under control, danger), size (e.g. small, big), and intensity (e.g. small, big).

When a user places or manipulates an icon on a map, the interface creates the new fact in an XML scheme. The following is an example of facts created by a user:

```
<fact action="add" x="100" y="11" t="142314">
  <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 helps its user by: (1) menus for deleting an icon on a map, and inspecting or altering its attributes (“update”); (2) menus for zooming in, zooming 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. A scenario describes the user’s world model. To create a scenario, an NLP module processes the list and converts it into natural language texts. It uses the grammar rules on figure 5.

```
S à  preposition time NP PP ()
NP à  N tobe ATTR1* | subject tobe AN ATTR2*
ATTR1* à  attr | attr conjunct ATTR1*
ATTR2* à  article attr-name tobe attr|
   article attr-name tobe attr conjunct ATTR2*
PP à  preposition street-name
N* à  article N
N à  people | building | vehicle
AN à  article event
```

Figure 5. The grammar rules of ISME

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

```
Around 14.23, a fire fighter is wounded on Steenstraat.
Around 14.25, there is a fire on Steenstraat; the status is under control and the size is small and the intensity is small...
```

4. Context-Aware Collaborative Information

By means of both iconic interfaces, users are able to communicate a collaborative information system (CIS) by client server connections. 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 of clients by measuring environmental variables, i.e. the selection on the location of objects in the environment of a user or the location of a user self at a certain time-range will be used to capture the information 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 (Φ) that are constructed by atomic expressions connected with logical operators. Each atom is a tuple ϕ = ($name_\phi$, $operator_\phi$, $value_\phi$). An example of a subscription (Γ) is

```
Γ(Φ) = (building=1) AND (fire=1) and
       (time=15.00) and (location=(99,9))
```

Each atom will have a relevancy value - $r(\Phi)$. This value will be increased if more observers report the same situation. A set of events $\varepsilon = (name_\varepsilon, value_\varepsilon) \mid \varepsilon \in E$ defines the content of a crisis event at a certain location.

The next step is to measure context-aware environmental variables. 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 $c \in \chi$ 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 the following equations:

$$\Phi_p(c) = \{\phi \mid P(r(\phi), c) \geq p\}$$

$$s_p(c) = \Gamma(\Phi^p_{sub}(c))$$

where *P* is a priority matrix to assign the priority *p* to each atom in Φ 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 latter 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:

$$MATCH(\phi,\varepsilon) = \{ \begin{matrix} true \Leftrightarrow name = name_\phi \cap operator_\phi(value_\varepsilon, value_\phi) \\ false, otherwise \end{matrix}$$

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

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

$s_p(c)$ = true means the received report is accepted with priority *p*. A set of accepted $s_p(c) \in E_\varepsilon$ 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. [1][9][10][11][13]. We also used semiotics approach to design and evaluate our icons [4]. This approach relates with how close the interpretation in a user’s mind is to what the icon represents [14]. For both interfaces, we performed a user test for each icon in the context on other icons based on the following equation [9]:

$Icon_i + Context_j + Viewer_k$ à $Meaning_{ijk}$

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

Our design concept provides navigation for users around icons by three ways: (1) grouping related icons in the same concepts to hint where an icon can be found [9]; (2) providing a distinctive appearance of a selected icon from the rest of unselected icons; and (3) the Lingua system in particular provides a real-time distinctive appearance of which icons can be selected according to syntactical rules. The design concept also supports fast interaction by providing an icon prediction system. We adapted an n-gram word prediction technique [15]. The probability of an icon string is estimated using Bayes rule:

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

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

6. Experimental 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” [2]. 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 it. In the last 3 tasks, we showed participants a map of a crisis event (for example, a 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 concept and ideas in mind using icons on both interfaces. The results also indicated that our target users still had problems in finding their desired icons. Some of the reasons were referring to problems in recognizing some icons. Other reasons were related to: (1) adaptation time; (2) the cognitive process to find more relevant concept to represent their message; and (3) due to limited provided icons, which made the user should have rethought another concept that could fit with the problem domain.

7. Conclusion

Two experimental icon-based communication interfaces have been developed. The first prototype is an interface for creating and sending an observation report using icon strings. The second prototype is an iconic 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 that users wanted to generate some icon strings, which were out of domain. Therefore, 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 relevance, fidelity and within timeline reports and shares them to a decision making module.

Our experimental results showed that both iconic interfaces could serve as communication mediator. Nevertheless, 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 cover more user requirements in mobile context use.

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