WEATHER ASSERTIONS FOR ENVIRONMENTAL DECISION-MAKING

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1. INTRODUCTION

Consider a situation in which a forest fire emergency manager monitors the fire danger over a number of forests. Fire danger is a complex problem that depends on many factors divided in three groups: weather, fuel moisture, and social activity. High temperatures and dry conditions decrease the fuel moisture, thus increasing the probability of fire. Lightening may cause a fire, and high winds can contribute to the quick spread of the fire over a large area. The emergency manager could use weather grids created automatically by analysis and prediction models that provide accurate data for various parameters with high spatial and temporal resolution, but this would be time-consuming and may not be appropriate in the case of emergency.

The existence of many sources of objective information concerning fire danger, the large volumes of datasets, and the dynamics of updating the datasets makes it difficult for emergency managers to combine the different data and make a clear and timely decision. Their jobs would be greatly eased if they were assisted by an agent (a computer program) that checks the gridded datasets every time they are updated and identifies the forests over which a threatening combination of factors is observed, thus prompting an investigation of the weather parameters contributing to the fire danger. Furthermore, the agent can "explain" its reasons for the alarm, thus guiding managers in their examination of the situation. Finally, the agent can provide information about the critical parameters using displays that emphasize the interesting aspects, thus enhancing assimilation of the information. The simple display shown in Fig. 1 contains signal lights (on the upper left corner), a summary text and a list of the forests affected by the high fire danger (at the bottom of the display), and graphs of the two critical parameters (at the top of the display).

This paper investigates the role of weather assertions, as opposed to the direct use of gridded data, in environmental decision-making. The approach of weather assertions has been implemented in MeteoAssert, Kerpedjiev (1994), a system designed to produce and organize assertions from gridded data. It can be used for planning agricultural or forest operations, such as spraying and fire fighting, that depend heavily on weather, as well as for predicting phenomena such as insect migration and fire danger. The decision-maker needs to create a mental picture of the weather situation in the context of the problem in order to make proper decisions. MeteoAssert fulfills this role: it summarizes weather gridded data fields into assertions that specify those aspects of the situation which are closely related to the particular problem, and presents them as a multimodal report.

2. ASSERTIONS AND DESCRIPTIONS

MeteoAssert converts gridded datasets into assertions about weather or weather-related characteristics referring to spatial and temporal objects called regions and periods, Kerpedjiev (1993). Some examples of assertions generated by the system are: "Low relative humidity in Pike National Forest during the whole day; High fire danger over the Front Range area in the afternoon; Max wind speed on the Plains 35 mph." The process of assertion generation is a sequence of transformations of objects such as grids and time series into a numerical or categorical parameter value. The numerical parameters provide certain statistical values such as mean value or maximum value, while the categorical parameters provide simple judgments such as high winds or low fire danger.

MeteoAssert also organizes the assertions in descriptions, coherent chunks of information, using certain discourse relations such as temporal and spatial description. Thus, a description is regarded as a deep representation of a report that is given to the decision-maker building a mental model of the situation. To enhance the effect of a report on the decision-maker, it is usually prepared in a multimodal form, i.e., various modes of presentation such as maps, text, and graphs are employed to convey the information to the user.

Descriptions are generated in response to queries defined in terms of three models: parameter, territory, and time. The parameter model defines the variables used in assertions and their domains. The territory and time models define the regions and periods with which the decision maker deals. The objects in a model are arranged by types (e.g., regions can be forests or counties) and are interlinked by certain relations (e.g., superregion, which is a region that contains another region). Each query is of a certain type, which tells the system how to organize the assertions. It can be a temporal, regional, or parametrical description. Some standard queries can be defined as triggers and processed each time new data are received; thus, up-to-date descriptions will always be available. Other

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queries are generated in the process of exploring the situation by the user.

3. PRESENTATION

Various techniques of presenting descriptions and accessing the information are being tested. They include generation of natural language text, tables, graphs, diagrams, and maps. Each medium is suitable for presenting certain aspects of the situation. Thus graphs are perfect for presenting time series. Maps can conveniently present the location of certain phenomena and therefore are most often associated with spatial descriptions. Diagrams allow for easy visual comparison of related parameters. Tables can virtually accommodate any type of description but are most often used for presenting lists of objects (e.g., regions with several attributes associated to them). Natural language text is used to present summary information, to link the presentation by referring to the other displays, to make evaluations and explanations, and to suggest actions.

The access to the information is of particular importance as the system fulfills both signaling and exploring functions. The signaling function means that the system takes the initiative to warn the user about a threatening combination of factors, as new data warrants. Most often this function is associated with triggers. To alarm the user, sound and simple displays such as a list of regions and a light representing the degree of hazard can be used. The user can then explore the situation by selecting the objects shown on the first display (regions and critical parameters) and a more detailed display will be produced that includes a graph showing the evolution of the parameter and an image of the parameter distribution over the region. At every moment a text message in a separate window explains the situation in qualitative terms.

The presentation subsystem consists of media generators that produce messages in the various modes and handlers that monitor the user actions (selecting from menus and clicking on existing presentations) and interpret them as requests for particular information.

5. CONCLUSION

The approach presented here may be useful in a variety of environmental decision-making situations. The essence of this approach is the reduction of large gridded datasets into a small number of assertions organized in descriptions. While the original datasets represent parameters describing the state of the atmosphere on a regular grid, the assertions provide characteristics that are closely connected to the particular problem and related to regions of interest to the user. A multimodal presentation facilitates the interpretation of the information by allocating the different pieces of information to media that support the interesting aspects of the event.

MeteoAssert, developed at NOAA's Forecast Systems Laboratory, was written in Microsoft Visual C++ and runs under Windows 3.1. It uses weather datasets produced by the Local Analysis and Prediction System, McGinley et al. (1991). These datasets have spatial resolution of 10 km and temporal resolution of 1 hr. The grid covers an area of 610 by 610 km.

A Basin Rainfall Monitoring System, Subramaniam and Kerpedjiev (1994), was designed under the principles presented in this paper and is used by flash flood emergency managers in Boulder County.

This approach is being studied within the FSL Dissemination Project, Small (1993), that is being developed to provide high-quality weather data to various groups of specialized users.

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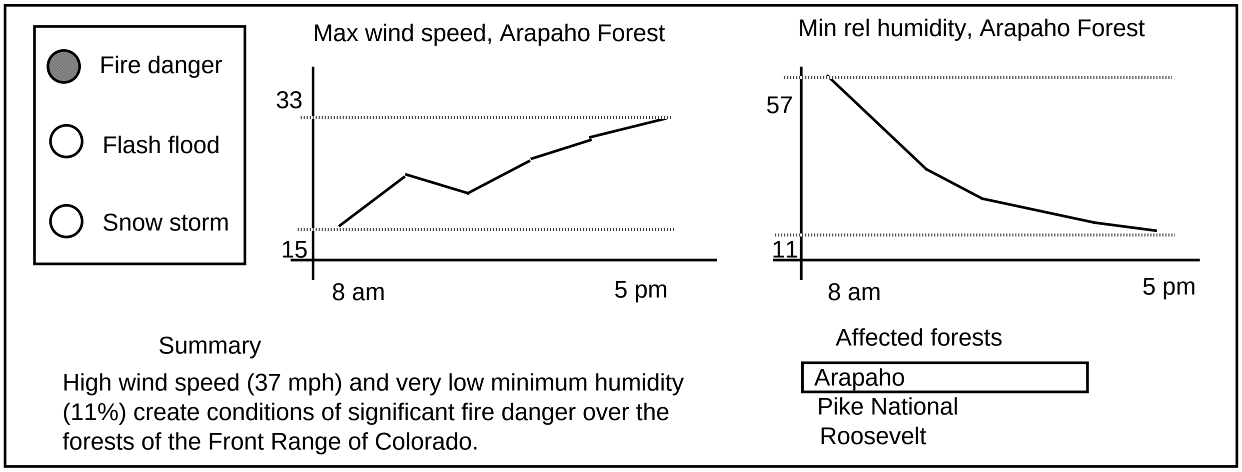

Fig. 1. An example of an assertion-based multimodal display.