A Prototype System to Extract Winter Weather Information for Road Users

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Abstract

Winter weather places a significant burden upon the economy as well as upon individual road users who must decide whether or not to make trips in uncertain weather conditions. There is a significant quantity of data available that is pertinent to the condition of the road surface in winter, but most of it is dispersed and thus not readily accessible to road users. To determine the road conditions for a 300 mile trip across Iowa, a road user would have to access at least nine different web locations.

This paper presents a system that automates the data collection needed for road users in such circumstances. The system determines, based on user inputs, which Internet sites need to be surveyed. The system then visits those sites, collects weather data from them, and finally presents the data in an easily read format for the road user.

While the system is currently somewhat limited, and can be improved in a number of ways, it nonetheless serves as a prototype system to demonstrate how more realistic systems can be developed and deployed. On the basis of the findings in this project, a more complete implementation of the system, which includes not merely current but forecast weather conditions, can be developed.

1. Introduction

A study in 1998 conducted by Standard and Poor’s DRI estimated the economic losses to States in the Midwestern USA as a result of a severe winter storm. The storm that formed the basis for this economic analysis was assumed to be severe enough to close roads within each State for a period of 24 hours. The economic losses varied by State between $30 million and $300 million per day. The losses arose from lost productivity, lost wages, lost sales, and lost taxes. Given these high levels of economic impact, it is no surprise that as an annual average about $2 billion is spent on direct winter highway maintenance activities (plowing and clearing roads of snow, and applying chemicals and abrasives), with estimates indicating up to another $3 billion in secondary costs due to winter weather on the highways.

These numbers suggest that better information about winter conditions on highways might help to alleviate some of these very high costs. Clearly the type of information that will have most value to the...
end user will vary significantly depending on the end user. The supervisor of a winter maintenance garage will have needs for much more specific and detailed information than a typical road user. The development of Maintenance Decision Support Systems is an attempt to address such detailed and specific needs (Pisano, 2000). However, the advent of the 511 Road Information Network suggests a significant need for tailored winter highway weather information (see e.g. Johnson and Tinkleberg, 2001) that is of value and benefit to regular road users.

The challenge of presenting such information is not that the data are unavailable. There are significant amounts of winter weather highway data available to road users, mostly via the Internet. However, collecting all such relevant data and presenting them in a way that gives knowledge to the road user is a greater challenge.

The specifics of this challenge are that a program or system must be developed that, based upon route input from the road user, can gather weather data from multiple sources and display it in a readily accessible manner. This paper presents a pilot implementation of this system. Specifically, the aim of this paper is to present a system that, given a start and end point on Interstate highways in the State of Iowa, collects temperature data from along the Interstate system between the start and end point, and presents those data graphically. Clearly, such a system is no more than a proof of concept. A working system would require a much broader range (beyond one State) which implies gathering data from multiple and diverse web sites. All the sites accessed in this study were part of the Iowa Department of Transportation’s (DOT) web site. The value of such a system would also be considerably enhanced if it could factor travel time into the information provided.

This latter feature would require a significant forecasting ability in the system. For example, if a user wishes to travel from Davenport (Eastern Iowa) to Council Bluffs (Western Iowa) the trip will likely take about five hours. Thus current weather conditions in Council Bluffs are of much less value to the motorist than the conditions (albeit predicted) in five hours time, when the motorist would arrive. Further, by making use of storm tracking data, it would be possible to indicate to the road user whether and where they might encounter snow fall on their trip. Such features will be part of a subsequent version of the system.

As indicated above, all data used in this version of the system were obtained from the Iowa DOT weather website (http://weatherview.dot.state.ia.us). The weather data available on this web site are collected by means of weather sensors. The main source of data for the Iowa Department of Transportation is their network of RWIS (Road Weather Information Systems) weather sensors. Iowa’s winter weather brings an average of 34 inches of snow annually and the Iowa DOT’s Maintenance Division is responsible for snow and ice control on the Interstate and primary highways.

2. Literature Review

Pressman [1997] presents the steps involved from data capture (first phase) to information processing (final phase). Data extraction is defined as the gathering of raw data from a data source. Poe et al [1998] differentiate between data and information. According to them, data are a collection of discrete elements. But when data are merged, aggregated, derived, sorted, structured and displayed they become information. Data integration is the process of consolidating,
converting and populating the discrete and disintegrated data files into a single data warehouse.

The custom networking concepts developed by Sun Microsystems are used in this work. The user specifies a start and end point for the journey of interest. The data of interest are extracted from each Uniform Resource Locator (URL) using a Java method that opens a network connection to that URL. Using various operators, data are read and information is derived. This information is then presented graphically to the road user.

Myllymäki and Jackson [2001] talk about web-based data mining using XML and Java concepts. Their approach is to identify the HTML source and map it to XHTML and XML format. Finally, they merge the results and process the data. Such an approach would doubtless be of considerable value in this particular application. However, it is perhaps more pertinent to consider the use of a variant of XML called RWML (Road Web Markup Language) currently under development (Kajiya et al., 2002) in Japan. Future work on this project will make use of RWML to obtain and display pertinent information, and will also be structured so as to tie easily into 511 services.

3. Overview of the approach

The method followed for data extraction in this paper is illustrated in the figure 1. The steps illustrated in the figure are

1. Identify the data source on the world wide web
2. Using the data extraction tool, extract the complete HTML statements
3. Format the HTML statements into the required information using the formatting tool
4. Show the results on an MS-DOS screen
5. Using the graph function, illustrate the results in a Java applet window

Figure 1: Overview of data extraction process
The system relies first upon specification of a start point and end point for the Journey. At present, these are manually entered, although a Java applet version (not used for reasons discussed below) allowed these locations to be chosen from a drop down menu. Once these locations are specified, the route is easily identified, and the program notes the RWIS sites that fall on the route.

These data then allow the program to identify the URLs that must be accessed to gather the pertinent weather data. The current version of the program extracts air temperature data from each RWIS site (again, as a demonstration – any of the supplied data can in fact be extracted). The air temperature data are then presented graphically, with air temperature in degrees Fahrenheit as the ordinate and RWIS station location as the abscissa.

4. Development of the System

As indicated above, this prototype system collects data on road weather conditions from various Internet locations. The data collected is tailored according to the route specified by the road user. The system then presents that information in a simple graphical form. The details of this process are given below.

4.1 Source of Information - Weather Sensors

A typical Road Weather Information System (RWIS) comprises of a network of weather sensors imbedded in roadways and bridge decks that capture real-time data. The sensors typically report

- Temperature of the pavement
- Amount of deicing chemical on the pavement
- Surface freezing point
- Subsurface temperature
- Condition of pavement- whether it is wet or dry

RWIS units also record data from environmental sensing devices located at the side of the roadway. These devices measure air temperature, relative humidity, dew point, visibility, wind speed, wind direction, amount and type of precipitation. After collecting the data, the RWIS units transmit the data to a central computer that converts the data into understandable information. This information is automatically routed to maintenance facilities responsible for deploying materials, crew and equipment.

Figure 2 shows the Iowa DOT RWIS stations along main highways as blue diamonds. Automated Weather Observing System(AWOS) are shown as red airplanes. The interstate highway I-80 has a number of RWIS stations placed from the east end to the west end of the state of Iowa. The information from these RWIS stations and other environment monitoring stations in Iowa is displayed in the Department of Transportation website (http://www.weatherview.dot.state.ia.us)

Detailed information about a particular location along the road can be obtained by clicking on the blue diamonds. RWIS information about Iowa City is shown in figure 3.
Figure 2: Map of Iowa highlighting the RWIS and AWOS stations
(Source: Iowa Department Of Transportation website, http://weatherview.dot.state.ia.us)

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>2/19/02 4:30:07 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Atmospheric Data</strong></td>
<td></td>
</tr>
<tr>
<td>Air Temperature</td>
<td>49° F</td>
</tr>
<tr>
<td>Dew Point</td>
<td>49° F</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>99%</td>
</tr>
<tr>
<td>Average Wind Speed</td>
<td>5 mph (4 knots)</td>
</tr>
<tr>
<td>Wind Gust</td>
<td>6 mph (5 knots)</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>SE (155°)</td>
</tr>
<tr>
<td>Precipitation</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Surface Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-218 SB Pavement</td>
<td>51° F</td>
</tr>
<tr>
<td>US-218 SB Bridge Deck</td>
<td>50° F</td>
</tr>
<tr>
<td>US-218 NB Bridge Deck</td>
<td>50° F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Sub Surface Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-218 SB Pavement</td>
<td>43° F</td>
</tr>
</tbody>
</table>

Figure 3: RWIS Information of Iowa City
(Source: Iowa Department Of Transportation website, http://weatherview.dot.state.ia.us)
The atmospheric data available are:

- Air temperature - temperature of the air measured approximately eight feet above the ground.
- Dew point - temperature at which air is fully saturated with moisture.
- Relative humidity - measure of the amount of moisture present in the atmosphere, expressed as a percentage.
- Average wind speed - average wind speed within a one-minute period, expressed in miles per hour.
- Wind gust - maximum wind speed within a one-minute period, expressed in miles per hour.
- Average Wind Direction - Average wind direction within a one-minute period, expressed as the direction the wind is blowing from.
- Precipitation - Precipitation in the atmosphere (not the roadway surface). Expressed as "Yes" (presence of some type of precipitation), "None" (precipitation is not occurring), or an indication of the specific type of precipitation.
- Surface temperature - measurement of the actual temperature of the roadway or bridge surface.
- Subsurface temperature - temperature approximately 18 inches below the roadway surface.

The prototype system uses a look-up approach to select which RWIS stations should be sampled. The road user, in the current form of the prototype, is required to select from a limited number of route options (e.g., from Davenport to Council Bluffs). The user selection is then used to instruct the system which Internet sites need to be accessed. For the route from Davenport to Council Bluffs, the system selects all RWIS sites along I-80 (there are nine such sites). With this information, the system then generates a graphical presentation of the road weather information.

4.2 HTML Source

The following figure shows the complete HTML source after using the data extraction tool. It contains all the semantics of the source.

Figure 4: HTML source
4.3 Required HTML Statements

From the above HTML source, the required HTML statement is filtered out. This is done by specifying the variable of interest. For example, to filter out the variable air temperature we specify it in the source code as

If (inputLine.indexOf("Air Temperature") > 0)

and the result is

Air Temperature</B></A></FONT></TD>
<TD WIDTH=50%><FONT SIZE=-1>74&deg; F</FONT></TD></TR>

The above is again subjected to further filtering process to extract the numeric value of air temperature.

4.4 Data (Refined form)

Using the filtering tool, the numeric value of air temperature is obtained. It is carried out using the following code

inputLine = inputLine.substring(307,312)

and the result obtained is

74&deg; F

4.5 MS DOS Screen

The resulting numeric values of air temperature are displayed on the MS DOS screen, as shown in Figure 4. Here, we have selected 9 RWIS sensor points that runs from east to west along Interstate 80 in Iowa. The first value is the value obtained from Davenport in the east and the last is that of Avoca in the west along I-80.

4.6 Java Applet Window
After all the values are shown in the MS-DOS screen, a Java applet pops up automatically with an illustrated graph.

![Graph showing temperature values between Davenport and Avoca on March 6, 2002](image)

The applet scales have the ability to adjust according to the temperature. For example, if the temperatures are in the upper 50’s the scale will start from zero and if the temperatures are in the 30’s it will start from a negative value.

The end result is thus a simple graphical presentation of road weather data in a form that is easily accessible by the road user. This process would greatly simplify the gathering of such data for road users, which in turn would make it much more likely that the data will be accessed by road users.

### 4.7 Future Work

While this system does simplify the collection of road weather data significantly for road users, it can be improved in a number of ways. First, the whole system should be web based rather than run via a separate application. The application based approach used herein was used because of security issues in accessing the Iowa DOT web site. Specifically, the site is protected by a firewall that limits access by Java Applets across the firewall boundary. However, use of XML (see e.g. Myllymaki and Jackson, 2001) would avoid these issues.

However, XML alone may not be the best solution. The new version of XML termed RWML (Kajiya et al., 2002) would be even more appropriate to this problem. Further, any implementation of this approach must be done within the context of the 511 Traveler Information systems currently being developed.

Two other issues should also be addressed in future work on this project. First, clearly the system must be expanded beyond a single State, and furthermore, a more dynamic route development system must be used. Second, in such a system, travel time must be incorporated into the presented data, so that temperatures for a
point 6 hours “down the road” reflect what the road user will find when they get there, rather than current conditions (which will be six hours out of date when they arrive).

Notwithstanding these substantial areas for future development, the current system serves as a useful and effective prototype system that can be relatively easily developed in the ways indicated in this section. Future work will address these needed developments.

5. Conclusions

In this paper, we have illustrated how to extract data and use it for a practical application. A person traveling westwards along I-80 through Iowa can gather data from each intermediate location without selecting and clicking on all the blue diamonds on his/her way and will be able to get back the necessary data automatically using this system.

The potential of extracting data from an internet source has been depicted in this paper. The Java application that provides the road data along the required stretch of road addresses the needs of the road traveler. The same application provides valuable information to maintenance personnel about the weather conditions at different points, which can be used as an input to an expert system.

This is now run as a Java application but our real aim is to run it as a Java applet and access it from a web page. The necessary applet code has been coded but we are unable to use it from a web site due to the built-in security features of the applet. Future implementation of the system will incorporate XML features and some forecasting abilities also, as well as going beyond the boundaries of a single State.

6. References

Heller, Roberts. *Java 1.2 Developer’s Handbook*. Sybex, California, 1999

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Iowa Department of Transportation. “What type of RWIS weather information is available?” [http://www.weatherview.dot.state.ia.us/edu/rwiswhat.htm](http://www.weatherview.dot.state.ia.us/edu/rwiswhat.htm)


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