The Development of Automated Real-Time Narrative Summaries (ARNS) Using Natural Language Generation Software for PORTS®

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***Abstract*-Since the 1960's, the Center for Oceanographic Products and Services (CO-OPS), the organization responsible for producing operational quality controlled current and water level products, has primarily focused on disseminating their products in numeric and graphical formats using the web and interactive voice as mediums. The CO-OPS is now developing a real-time textual summary product using natural language generation (NLG) software. When completed, this product will generate a "worded" representation of the observations and predictions now displayed and spoken in digital form. Its primary purpose will be to provide a set of synoptic phrases that reflect the latest set of observations within a PORTS location that are easy to read and comprehend, thus relieving the user of viewing and interpreting many discrete digital observations.**

I. INTRODUCTION

The Automated Real-Time Narrative Summaries (ARNS) product would consist of a brief, single paragraph summarizing the observations received from numerous sensor data. The paragraph would be available via the CO-OPS web site for each PORTS [1] and through an interactive voice response system [2] already used to disseminate discreet PORTS observations via toll free numbers. The primary benefit would be the ability to read a brief paragraph of less than 100 words and understand what the behavior of the estuary is in real-time with little or no interpretation on the users' part.

This paper focuses on developing a textual product. One could argue that a textual product is in some ways going backwards in time and ignoring the power of graphical displays of information. There is no doubt that graphical representations of data have been and are valuable products to display data. The cliché "a picture is worth a thousand words" still applies. Furthermore, if the user would like to visually inspect data and take the time to view details of trends and comparisons over time, the graphic or time series is still the product of choice. Other mediums like voice are also excellent ways of disseminating data and information. If you are a pilot of a vessel, traveling down a channel and you need real-time data for a particular station within a PORTS estuary or harbor, a real-time voice system can prove to be very helpful by simply dialing a toll free number. CO-OPS currently provides all these products: data screens, time series graphics, and a toll free voice system, all in real-time.

There is a need however, for users that would benefit from a "complete" oceanographic picture of what is going on within the entire estuary in a relatively short period of time without visually inspecting many observations, mentally analyzing the data and making judgements as to how it all "fits together."

II. NWS'S COMPUTER WORDED FORECAST: APPLYING THE CONCEPT FOR PORTS

Under the guidance and direction of Dr. Harry Glahn of the National Weather Service (NWS), the NWS has developed a product to disseminate text phrases that represent the numerical values generated by numerical forecast models [3]. The product called Computer Worded Forecast (CWF) has evolved into an interactive version that is now used by the weather forecasters around the country to assist in formatting forecasts for the public. The original software for the CWF was written in Fortran and used a matrix of digital values representing forecasts for various elements of weather such as ceiling, temperature, visibility and winds as input. Based on guidance from the NWS Operations Manual [4], the CWF software generated phrases composed of standardized, static text with inserted quantitative and qualitative values and adjectives.

This will be the basic concept of ARNS. Digital values from flat files in a format called PUFFF (PORTS Uniform Flat File Format) [5] will be ingested into the

ARNS software suite and used in conjunction with static phrases to create textual summaries. Unlike the CWF, the phrases will not be forecast-based but observation-based with some predictions for currents and water levels when appropriate and available.

Fig. 1 shows the PORTS data screen for Narragansett PORTS at 1:36 AM EDT on March 6, 2003 as displayed on the CO-OPS web site (http://tidesandcurrents.nos.noaa.gov) Referring to Fig. 1, there are five water level stations configured with meteorological sensors as well as a stand alone meteorological sensor at Prudence Island. There are four locations where CT (conductivity, temperature) sensors generate observations. There are two ADCP (Acoustic Doppler Current Profiler) instruments. Predictions for currents are provided at the Providence location. In all, there are 35 observations for the user to read and comprehend. Given a rather uneventful real-time sample where wind events and other atmospheric influences are not in play, this would not be a difficult task. However, it can be quite challenging when the observation picture is changing. Meteorological events passing through and across the estuary can result in significantly different observations received from one or more portions of the estuary. This requires more time of the user to interpret and comprehend what is actually happening oceanographically and meteorologically within the estuary. In addition to the challenge of comprehending a changing real-time oceanographic and meteorological picture, the sheer number of instruments and associated observations to view can be time consuming if you are interested in a summary. Some PORTS have more than 35 observations, and in the near future, the CO-OPS is planning to incorporate other sensors into the PORTS suite of instruments including wave data and visibility. The more data that the user must ingest and mentally analyze, the more important it is to have the ability to summarize the data for the user. The graphs will still provide the individual station detail and the voice will still provide the very important convenience of getting data to the user; however, the summaries will allow the user to get a textual “snap shot” of the bay by reading less than 100 words.

III. CONCEPTUAL DESIGN

ARNS must be able to ingest real-time data for all instruments within all PORTS installations every six minutes, prepare the data for the summary generation software, make decisions about how to phrase the summaries based on predetermined rules and cases, generate the textual product, and disseminate the textual phrases. Data will be ingested into ARNS using the PUFFF. PUFFF are already available and used by other CO-OPS applications. The data contained in these files will be used as a basis for creating summaries every six minutes. In the absence of an operations manual as was used by the National Weather Service in their development of CWF, the

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Narragansett Bay PORTS, NOAA/NOS at  1:36 pm EST  March  6, 2003
------------- TIDES ----------------------------- CURRENTS --------------------
Providence      ***************: Providence                 0.1 kts.(S), 296°T
Conimicut Light 0.9 ft.,Falling: Fall River                 0.1 kts.(S), 263°T
Fall River      1.2 ft.,Falling: Quonset Point              0.5 kts.(E), 183°T
Quonset Point   1.0 ft.,Falling:
Newport         0.8 ft.,Falling:
                               :       (F)lood, (S)lack, (E)bb, towards °True
-------------------- Wind Speed/Dir ------------------ Air Pressure -- Air Temp
Providence          10 knots from N  , gusts to  17    1009 mb          25°F
Conimicut Light    ********************                1007 mb          25°F
Fall River          16 knots from N  , gusts to  20    1009 mb,Rising   27°F
Prudence Island     14 knots from N  , gusts to  18    1007 mb,Rising   26°F
Quonset Point       23 knots from NNE, gusts to  43    1007 mb          26°F
Newport             13 knots from NNE, gusts to  17    1009 mb,Rising   26°F
----------------- Salinity -- S.G. -- Water Temp -----------------------------
Providence        12.9 psu   1.011       35°F
Conimicut Light                          34°F
Fall River        21.7 psu   1.018       35°F
Quonset Point     28.7 psu   1.024       33°F
Newport           31.7 psu   1.026       34°F
-------------------------------------------------------------------------------
 **** - Data not displayed as a result of quality control monitoring. For more
 information, go to http://co-ops.nos.noaa.gov/corms_status.html, or call CORMS
at 301-713-2540.
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Fig. 1

decisions as to how to phrase the summaries must be based on experience and rules information gathered from the experts. Therefore, this application lends itself to a knowledge based approach where rules and cases are developed by experts to place into text, those observations received each six minute sampling period. Although rules to help the software "decide" whether to describe the currents as flooding or ebbing would be quite simple to create, it is hoped that with additional information conditions such as eddys, surface shear and counter currents could be described. Similarly, rules to describe the behavior or state of water levels as rising, falling or at slack water would be quite simple to create. It is hoped that conditions such as extreme high water that could introduce flooding, storm surge or extreme lows could be described. To incorporate these rules (based on expert knowledge) and to use them in deciding a phrase to use, knowledge and language translation technology must come together. Natural language generation and processing technology can provide such software for use in ARNS.

Natural Language Generation (NLG), also referred to as text generation, is a sub-field of Natural Language Processing (NLP) and includes computational linguistics. Natural Language Processing is a technology which involves converting spoken or written human language into a form which can be processed by computers, and vice versa [4]. Some of the better-known applications of NLP include voice recognition software which translates speech into input for word processors or other applications; text-to-speech synthesizers which read text aloud for users such as the hearing-impaired; grammar and style checkers which analyze text in an attempt to highlight errors of grammar or usage; and machine translation systems which automatically render a document, such as a web page, in another language. NLG applications can complement tables and graphics to make information instantly intuitively accessible [6].

So how much difference would there be in one user's view and interpretation of a PORTS data screen over another? We provided three very experienced oceanographers with samples of data screens from three PORTS, Narragansett Bay, Tampa Bay and Houston/Galveston.

Each participant was asked to summarize the data in as few words as they could while still providing a "picture" of the estuary of interest. We also asked them to tell us the length of time it took them to complete the task. We felt the time factor was important since the data screens, as with all CO-OPS real-time products, refresh approximately every six minutes. Even though the results do not qualify as a scientific study, they serve as a small sample of how experienced oceanographers can and do interpret data differently. Of the three participants, the longest summary was 900 words, followed by 578 words and 445 words. The amount of time needed to complete the summaries was 55 minutes, 2 hours, and 15 minutes, respectively. To demonstrate the clear differences in the detail and syntax provided by the participants, we have included excerpts from each of the three participants' summaries:

Water level excerpts from each of the three participants:

- Tides are falling at all stations in Narragansett Bay PORTS (as of 1:36 pm EST on 3/6/03).
- At this time, the water levels are falling throughout Narragansett Bay. The water levels are close to MLLW as indicated by the slack currents at Providence & Fall River.
- For stages of tide relative to Mean Lower Low Water, the tide at: Providence is "no report at this time," Conimicut Light is 1.2 feet and falling, Fall River is 1.2 feet and falling and Quonset Point is 1.0 feet and falling

Currents excerpts from each of the three participants:

- Providence is approximately slack at 0.1 knots, with direction towards 296 degrees true. Fall River is approximately slack at 0.1 knots, at a direction towards 263 degrees true Quonset Harbor is ebbing at 0.5 knots, at a direction towards 183 degrees true.
- ... slack currents at Providence & Fall River. At Quonset Point (further down the Bay) the current is still ebbing @ .5 kts.
- Currents are slacking at Providence and Fall River but ebbing at Quonset Pt. The directions are all indicated.

Wind excerpts from each of the three participants:

- The gusts range from 17 to as high as 43 at Quonset Pt.
- The winds over the bay are from the north or NNE and gusty. They range from 10 knots at Providence to 23 knots at Quonset Point, lower gust speeds of between 17 & 20 knots were reported at the other locations.
- Providence winds are 10 knots from the north with gusts to 17 knots. Conimicut Light winds are not reporting at this time. Fall River winds are 16 knots from the north with gusts to 20 knots. Prudence Island winds are 14 knots from the north with gusts to 18 knots. Quonset Point winds are 23 knots from the north-northeast with gusts to 43 knots.

Although all the summaries are accurate, there was no consistency in the level of detail, format, syntax or order of reporting. ARNS would substantially improve these reporting attributes. ARNS would take the data, input it into a NLP software package and based upon rules and cases, generate a NLP output in the form of a summary. CO-OPS has had success in using knowledge based systems in the past. The CO-OPS has developed a real-time data quality monitoring system with embedded intelligence using a Commercial Off-the-Shelf (COTS) package called MindBox. It will be the intention of CO-OPS to continue to seek a COTS solution in developing ARNS.

The following is an example of what the ARNS product would produce using the same data screen (Fig. 1) as the participants used in their summaries.

> *Here are the latest observations for Narragansett Bay PORTS valid at 1:36 P.M., March 6, 2003. The water levels throughout the Narragansett Bay are falling and are close to MLLW and are within .3 feet of the predicted values. Winds are gusty, generally from the North, with the highest gust of 43 knots at Quonset Point. Currents are less than 1 knot and at slack water at Providence and Fall River while ebbing at Quonset Point moving in a general southward direction throughout the lower Bay. The average bay water temperature is 26 degrees.*

Several companies provide NLP applications software. Companies like CoGenTex, Inc. have developed applications for meteorological data in the past [7]. CO-OPS will conduct a thorough market survey to select the COTS package and will use a detailed requirements document and selection criteria document in the process.

IV. CONCLUSIONS

The National Weather Service has proven that a textual summary product can be very helpful in capturing, interpreting, and summarizing digital data for their forecasters. We believe this same concept can be applied to the digital observations received by CO-OPS from the many instruments associated with PORTS. We also believe that the product could be extended for use in describing the data CO-OPS receives from their National Water Level Observation Network (NWLON). Clearly graphics and voice will remain as they are today as excellent mediums for disseminating CO-OPS data and information. However, CO-OPS is continually seeking new ways to help the users receive and comprehend our data to satisfy their many needs. With the existing and projected growth of CO-OPS operational programs, the development of Automated Real-Time Narrative Summaries (ARNS) can only help as an addition to our product suite. This project will be one that must combine human expertise and experience with state-of-the-art knowledge based software technology. It is sure to be both interesting to develop and very beneficial to the CO-OPS and its users.

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