DOAS: A Drought Online Analysis System with Constraint Databases *

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The *Standardized Precipitation Index (SPI)* [5] is a common and simple measure of the intensity and duration of drought at certain measured point locations. We interpolate this original point-based SPI data using a shape function-based interpolation [3], which is the most accurate among a number of alternatives [2], and represent the result in a constraint database [1, 6].

A *drought event* occurs any time the SPI is continuously negative and reaches an intensity of -1 or less, and it ends when the SPI becomes positive [5]. This recursive definition is difficult for most database systems to implement and visualize.

The *Drought Online Analysis System (DOAS)* uses a constraint database to represent the spatio-temporal data and allows both SQL and recursive, namely Datalog, queries which are high-level and easy to maintain. DOAS is a server-based and three-tier spatio-temporal system and supports animation of spatio-temporal results.

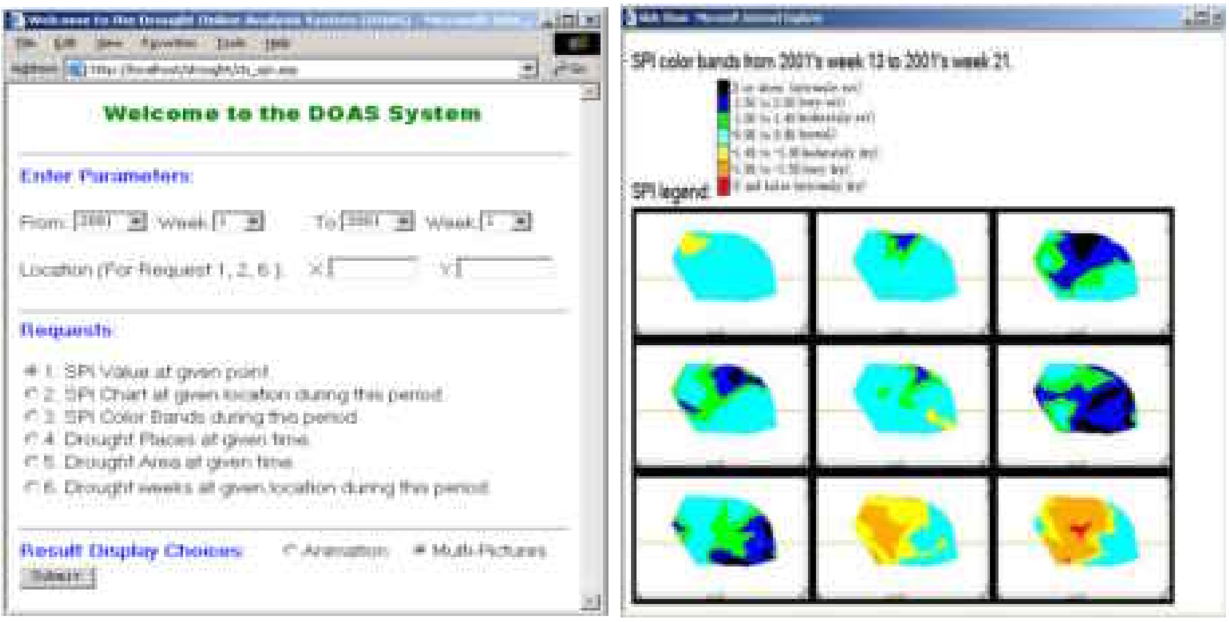

Figure 1. DOAS menu page (left) DOAS answer to query 3 (right).

The DOAS system implements six Datalog and SQL queries callable from a top-level menu as shown in Fig. 1.

We illustrate three queries on the next page.

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1. The right side of Fig. 1 shows a *color band display* of the SPI values at nine time instances. Instead of such a static display, DOAS users can also see a smooth animation of the spatio-temporal data on the screen.

2. The recursive definition of drought in [5] can be expressed in Datalog by:

$$\begin{array}{lll} Dry(x,y,t) & :- & SPI(x,y,t,s),\ \ s \le -1.0,\ \ SPI(x,y,t-1,s_1),\ \ s_1 < 0. \\ Possible(x,y,t) & :- & SPI(x,y,t,s),\ \ s > -1.0,\ \ s < 0. \\ Drought(x,y,t) & :- & Dry(x,y,t). \\ Drought(x,y,t) & :- & Possible(x,y,t),\ \ Drought(x,y,t-1). \end{array}$$

3. Based on the $drought$ relation, now we can calculate the number of weeks that location (P_x, P_y) is in drought during the time period (T_{start}, T_{end}). First, we use Datalog to find the weeks that the given point is in drought as follows:

$$Drought\_time(week)\ \ :-\ \ Drought(P_x, P_y, week),\ \ week \ge T_{start},\ \ week \le T_{end}.$$

Second, we use SQL with aggregation to find the total number of weeks as follows:

$$\begin{array}{ll} Create\,View & Number\_of\_weeks(weeks) \\ Select & count(Drought\_time.week) \\ From & Drought\_time \end{array}$$

Advantages of DOAS:

1. **Stores Interpolation Results.** DOAS needs to execute the interpolation function only once, then it can store the result. Many GIS systems [4] will not store the interpolation result and need to execute an interpolation function for every query that needs the interpolated data. Hence DOAS is faster on queries using interpolated data.

2. **Supports recursive queries.** Recursive queries are *not expressible* using the basic query languages of GIS systems. Some relational database and knowledge-based systems provide recursive queries, but they do not provide spatiotemporal data representation. Hence the drought query cannot be expressed in any known system in any easy way.

3. **Easy to maintain.** Other systems usually require some special functions to be written in a programming language like C or C++ and added to a library to implement queries that are easily expressible in DOAS using standard SQL and Datalog queries, which are simple, declarative, high-level, and easy to maintain.

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