Development of Internet Tools for Calculation and Prediction of Soil Hydraulic Properties

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Abstract. A prototype internet tool is proposed on a Web page for users who are not soil physics professionals to grasp soil hydraulic properties. The prototype includes a Java model to simulate infiltration into unsaturated soils and a client-server model to predict the simultaneous transfer of water, heat and salt in freezing unsaturated soils. Although further discussion is needed on the copyright and priority of the program, public domain systems using the internet likely will be dominant in the discipline of soil physics. The internet offers enormous potential to provide soil information, especially for soil database systems as GIS.

INTRODUCTION

The internet is now an increasingly powerful and useful tool in various fields, including soil physics. If expert programs are available on the internet, it would be convenient and helpful for many users to obtain information on soil characteristics and related properties. Several attempts to use a Web page for education have been reported at the annual meetings of the American Society of Agronomy during the past few years [*Johnston*, 1995; *Turner*, 1996]. However, few attempts have been made to run a program on a Web page because of current copyright laws. The purpose of this study is to propose a prototype internet tool, which includes a client-server model and a Java model, on a Web page for users who are not professional soil scientists. In the present paper, general characteristics are summarized for each model, and specific sample Web pages are proposed. This is followed by a discussion of current problems of public domain systems in the internet era.

MODEL TYPE

Client-Server Model (CGI model)

The Common Gateway Interface (CGI) is a way of interfacing external programs with information servers such as the HTTP web server. Since the CGI is important for building a client-server model, "CGI model" as used hereafter will refer to the client-server model. Most Web pages are static and are retrieved by the server on request. In a CGI model, however, a program can be executed each time it is requested, and its output is then given to the server as the document or the image data for the client. Figure 1 shows a relationship between a client and a server. The CGI model has an important advantage for constructing a database system because the server can allow access to databases via the Web. On the other hand, CGI has the disadvantage of potentially overloading the server when many user requests are received at the same time (Table 1).

Java Model

Java is an interpreted, object-oriented, portable, secure, multi-threading language. Many web browsers have now the ability to download and execute Java code segments over the internet. This means that a safe interpreter environment can be combined with a web browser to allow code to be retrieved and executed at the client site. Figure 1 shows a schematic

TABLE 1. Comparison of Client-Server and Java Models

	CGI model	Java model
Merit	Database	Animation
Demerit	Overload to server	Short program only
Sample	Freezing	Infiltration

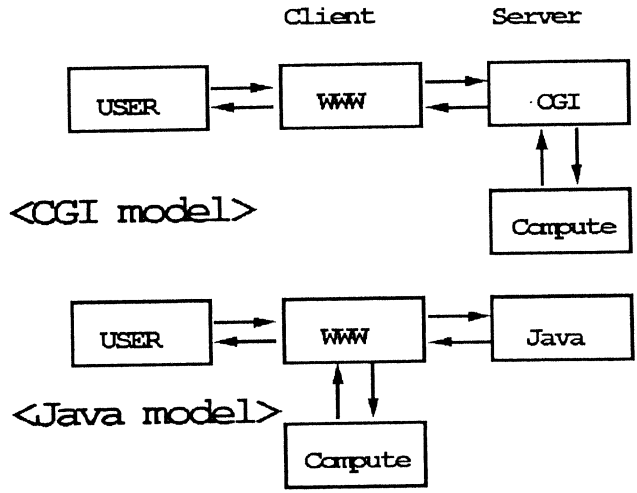

Fig.1. Model type constructed in the study.

diagram of the CGI and Java models. While in the CGI model a program runs on a server, in the Java model the program "applets" are retrieved to run on the browser window of a client. Since the program runs on the client's browser window once retrieved, a client can see the calculated results as document, image or animation without causing a traffic jam on the internet. Java may become much more widely used, and many more class libraries and new interface objects should become available. One potential problem could be the degree of difficulty of integrating Java code with code written in other languages. Because of this problem, Java programs are now generally limited to relatively short, although many useful program resources written in FORTRAN by soil scientists likely will be converted to Java code in the near future.

SAMPLE PROGRAMS

As a prototype internet tool for users who are not professionals in soil physics, two models – CGI and Java – are made available on a Web site (http://buturiPc6.bio.mie-u.ac.jp/openpro/index.html).

CGI Model for Simultaneous Transfer of Water, Heat and Salt in Unsaturated Frozen Soils

Normally, CGI programs are written in various languages depending on the system, such as C/C++, PERL and UNIX shells. In this study, UNIX shells (csh and sh) are used for the

user interface windows.

When a client accesses the URL of the CGI model, the client will find an input window which contains several parameter boxes for the initial and boundary conditions of the simulated soil (Fig. 2). When the "GO" button clicked after inputting appropriate parameters, the parameters are delivered to the CGI server in a laboratory via the internet. The CGI server has a program that calculates water content, salinity and temperature profiles during the freezing process according to the initial and boundary conditions given by the client. The program is rewritten in the C language from the BASIC code developed by the author [*Mizoguchi*, 1990]. Once the calculation is completed, the server returns a result menu to the client. When the client clicks a title in the result menu, the calculated profiles are shown in the browser window. Figures 3 and 4 show the calculated results for the temperature profiles and the redistribution of water, respectively.

Calculations in the CGI model are performed by a server. The performance of the calculation hence depends on CPU of the server and the number of users who are accessing the server at the same time. The more users access simultaneously, the worse the performance becomes. If the server has a powerful CPU, a single user will be comfortable to get the results. However, if several users access to the server at the same time, they might abort the calculation because of frustration caused by heavy traffic. Therefore, the CGI model may be suitable only for use by a small group.

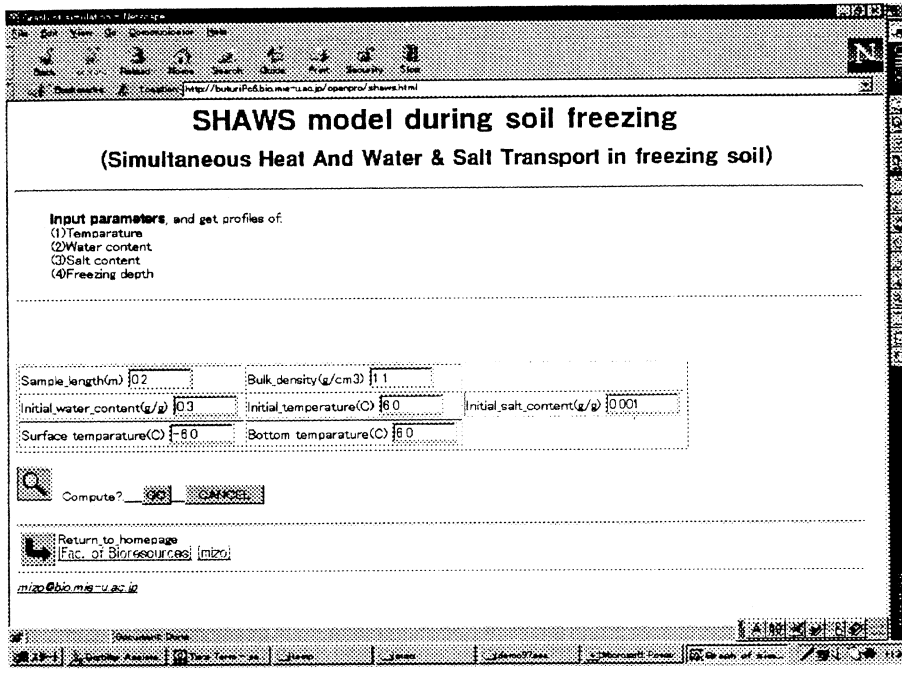

Fig. 2. Input window of a client-server model (CGI model) with parameter boxes for initial and boundary conditions to predict simultaneous water, heat and salt transfer in unsaturatedfrozen soils (http://buturiPc6.bio.mie-u.ac.jp/openpro/index.html).

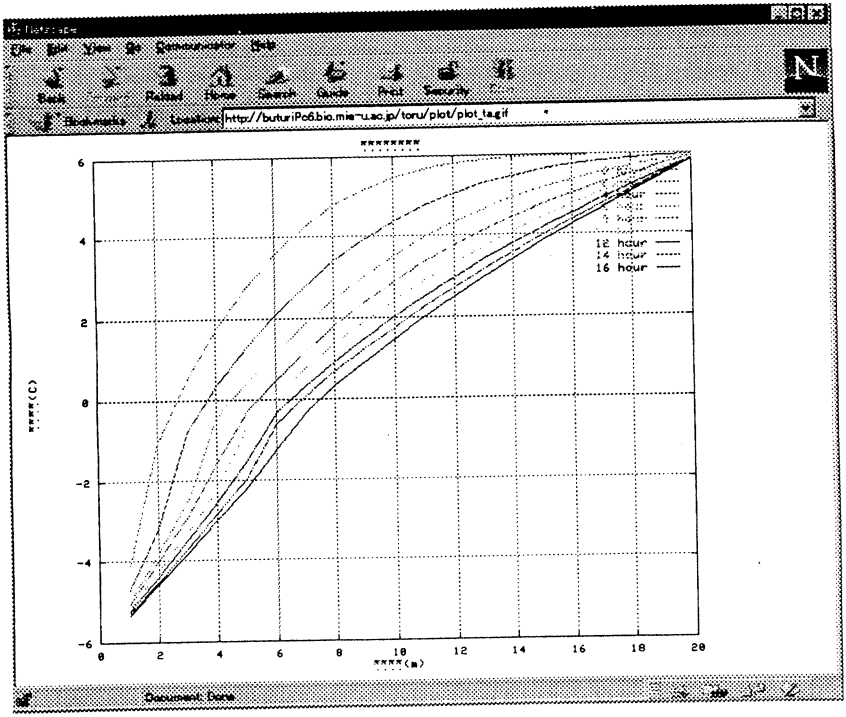

Fig. 3. Calculated temperature profiles in unsaturated frozen soil simulated with client-server model.

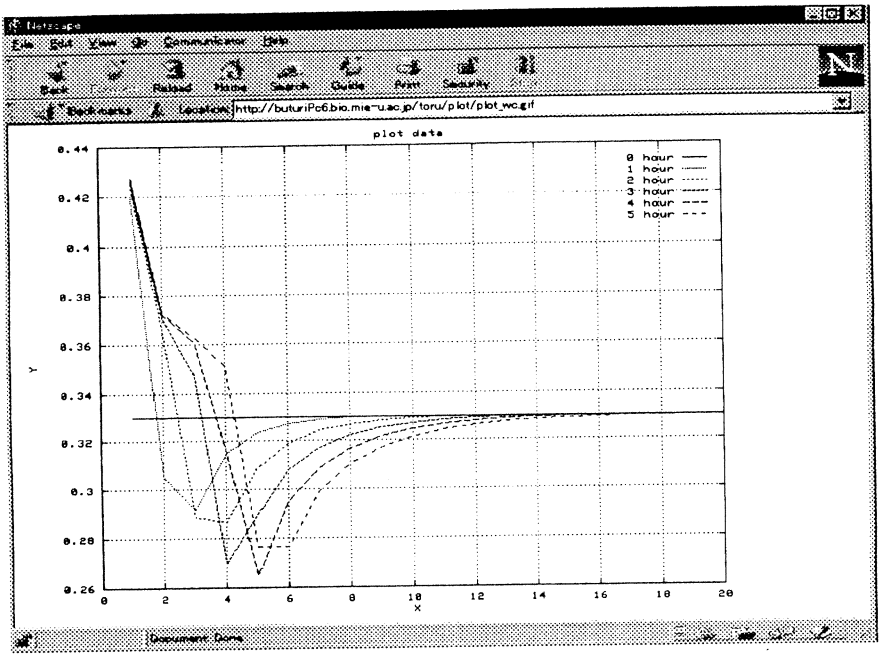

Fig. 4. Calculated redistribution of water in unsaturated frozen soil simulated with client-sever model.

Java Model for Infiltration into Unsaturated Soils

The Java model is better than the CGI model with respect to the traffic problem because the client can execute the Java program on the client's own computer after retrieving the Java code via the internet. Figure 5 shows the Java model developed in this study for infiltration into unsaturated soils. The program was converted to a Java code from the BASIC code published by *Campbell* [1985].

By using the Java language, the Java model also has the same interface window as the CGI model. When a client accesses the URL of the Java model, he or she will first get a Java code from the server located in a laboratory and find an input window (Fig. 5) before a result window (Fig. 6). The input window is for specifying the initial and boundary conditions of simulation, similarly as for the CGI model. The result window is to animate the redistribution of the water content in the soil. When the "COMPUTE" button is clicked after inputting the appropriate parameters, the calculation will start on the client's computer, and provide an animation of infiltration into an unsaturated soil. While the CGI model shows only one window, the Java model can show several windows at the same time. This characteristic of multi-windows in the Java model will be profitable for better understanding the simultaneous transport of mass and heat in soil.

Although the client may become frustrated while retrieving a Java code from the server, once the code is retrieved the client can run the program according to the performance of the client's computer not the server's.

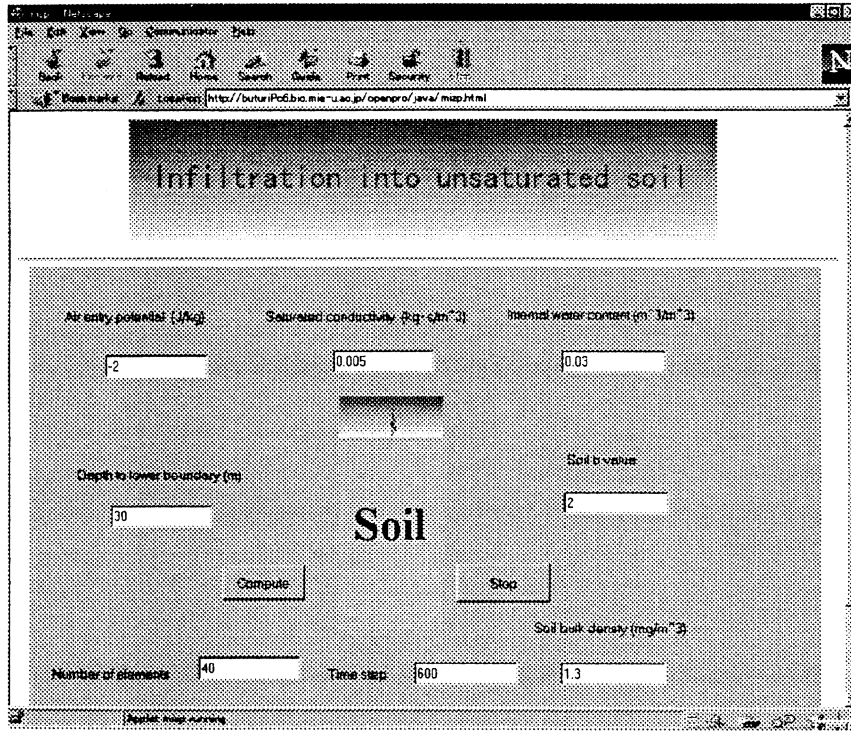

Fig. 5. Input window of a Java model for specifying the initial and boundary conditions needed to predict infiltration into unsaturated soils. A client will first obtain a Java code from the server (http://buturiPc6.bio.mie-u.ac.jp/openpro/index.html).

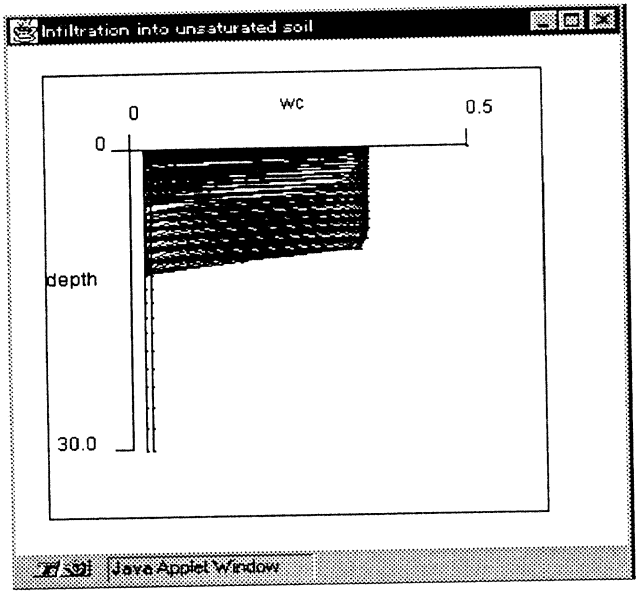

Fig. 6. Calculated redistribution of water during infiltration into an unsaturated soil. The redistribution of water is shown in real time. The characteristic of multi-windows in the Java model will elucidate simultaneous heat and mass transport in soils.

DISCUSSION

The internet is originally a computer network built up by UNIX and PDS (Public Domain Software) with public-domain source programs. Therefore, even if the original developer converts the programs to a Java or CGI model so that it can run on a Web page, most users will understand that the copyright and the priority of the program belong to the developer. However, if someone else converts the programs to a Java or CGI model on a Web page, he/she will need to express the name of the original developer in the converted program so as to protect the priority of the program developer.

Soil physics has yielded many useful program resources for years. However, most of these programs are not fully utilized, nor have they always satisfied the users; even their existence is often not publicized well. Worse, since the programs have been written in FORTRAN for DOS, they have the difficulty of running on window systems, which are now rapidly progressing. To solve these contemporary problems, Java and CGI models are quite promising. If a program can be converted to Java code, anyone can use the resource regardless of the Operation System (OS). Even if it is difficult to convert the program to Java code, users can use the resource by using the CGI model.

One potential problem when building a public domain system using CGI and Java models is who should authorize the programs. An authorized organization should manage the Web page containing the reliable programs. Once the Web page is authorized, active researchers can link the resources to soil database system such as Geographical Information system (GIS). The interaction between the simulation programs and the database will give a powerful internet tool to students, engineers and scientists who are interested in soils.

CONCLUSION

A client-Server model (CGI model) was constructed for predicting simultaneous water, heat and salt transfer in freezing unsaturated soils. A Java program was also developed on a Web page for infiltration into unsaturated soils. The internet system using CGI and Java models likely will become dominant in the soil physics discipline, which has provided much useful information in soil science, especially when making use of soil database systems such as GIS.

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