FINAL REPORT

Software Toolkit for Basic & Applied Vision Research

NEI SBIR Grant # R44 EY12444- (01-02)
Project Period: January 1, 2001 – March 30, 2003
Principle Investigator: Dr. Lawrence H. Boyd,
Pasadero, Inc., Tempe, Arizona

Field Consultants
Dr. Ian L. Bailey, Dr. Scott Fitz, & Dr. Kuang-Mon Tuan
Software and Website Development
Stephen Boyd, Dr. Scott Fitz, & Wes Boyd
Report Prepared by Dr. Lawrence H. Boyd
June 25, 2003

CONTENTS

This report can be viewed electronically on the ProtoGenie Website at
http://www.protogenie.com/report.html

The toolkit can be browsed and executed at
http://www.protogenie.com

FINAL PROGRESS REPORT

Project Title: *Software Toolkit for Basic & Applied Vision Research*
NEI SBIR Grant # R44 EY12444- (01-02)
Project Period: January 1, 2001 – March 30, 2003
Principle Investigator: Dr. Lawrence H. Boyd

SUMMARY

Propelled by the escalating costs of research software and the ever-widening communication and technology gap separating researchers and programmers, this NEI SBIR project developed a generic, menu-driven, do-it-yourself toolkit for vision scientists and researchers of all fields and disciplines. Five years in the making, the first prototype was implemented as a conventional application in C++ by software engineers under contract. With the coming of age of the Internet, the final version called ProtoGenie was built for researchers by researchers completely online to become the first user-developed, open-source, platform-independent, universally accessible, online research software authoring kit for researchers. ProtoGenie makes protocols that are used to define and guide events in experiments and other studies. New protocols are made from existing protocols selected from hundreds of typical research studies and protocols built by ProtoGenie researchers and online users. The first release supports classical experiments, clinical trials, laboratory trials, surveys and online polls, and observational research. Other methods and fields will quickly follow. This do-it-yourself software development system can be viewed and evaluated at http://protogenie.com, where it is already in use and free to new users.

PROPOSAL OBJECTIVES

The objectives of Phase II research were to implement the authoring toolkit for researchers called Vlab (Now called "ProtoGenie."), including the following:

1. ***Refine and expand VLab (ProtoGenie) basic infrastructure and process designer.***
   This objective was completed to the last detail. However, the coming of age of the Internet presented the opportunity to implement this toolkit completely on line. This was done. This approach is vastly superior to the conventional C++ application because it makes the researcher's toolkit platform independent and universally accessible. Moreover, Webcentric technology made it possible for our project researchers to design and write the program ourselves, rather than using a commercial software developer. This removed the major obstacle to creating an application and user interface that genuinely fits researchers' needs. Online application also presented the opportunity to make this toolkit a completely open-source development environment that virtually guarantees that it will evolve with use to support more methods and fields and special applications.

2. Design and implement Vlab (ProtoGenie) Component Library

With the change in the architecture of the toolkit for online implementation, components became "protocols" that would be used as templates for building new protocols. Protocols were written to support five major methods, classical experiments, quasi-experiments, clinical trials, laboratory trials, survey methods, and observational methods. The primary templates involved vision research, but the operations are completely generic with respect to field. Staff and future users will extend support by developing protocols for archival analysis, case studies, longitudinal and cohort studies, single subject experiments, industrial materials research, program and product evaluation, and clinical applications, such as diagnostic systems. This software also supports department and programmatic applications such as campus computer support programs, scientific method curricula, programs for people with disabilities, global conference rooms, and online governance and virtual management,

ACHIEVEMENTS

1. First Major Toolkit Online

   ProtoGenie is unique for its implementation completely on the Internet, becoming the first extensive online authoring tool for creating research software. This innovation is significant because the technology for implementing large applications online is still in its infancy and many problems had to be solved. Among the practical consequences of the online application is that it enabled an open-source environment in which researchers could create the authoring system itself. Researchers can write their own applications using the system and they can access the system virtually anywhere and on any computer with an Internet connection.

2. Research Software Built FOR Researchers BY Researchers

   ProtoGenie is unique among computer applications and authoring software because it was designed and written BY researchers FOR researchers.

3. Research Software Built on the Principle of Renewable Software

   ProtoGenie is unique because it is built on the principle of "renewable software," which holds that research software should never be used once and thrown away. In the ProtoGenie environment, new research software is archived and used again in whole or in part as templates for new research. In essence, we treat research software once built as a capital asset rather than an expense.

4. Slashes the Costs of Research Software

   Because research software can be built by non-programmers using ProtoGenie, the costs in time and money for high-priced software engineers and programmers are virtually eliminated, thereby dramatically reducing the cost of building research software.

5. Supports Small Science and Small Budgets

   By the very nature of the Internet, ProtoGenie fosters the decentralization of research and encourages research by small organizations and projects with small budgets. Among other

implications, federal research funding agencies and ultimately the public should be major benefactors of ProtoGenie through the reduction of the budgets of funded organizations.

6. User Interface Built to Reflect the Logic of Research

   The user interface of ProtoGenie is unique because it was designed by the researcher-developers to meld the logic of research with the familiar look and feel of the Web. Simplicity makes it useable at all levels of technical skills and age groups, including use in science education at all levels.

7. New Global Research Environment

   The online sharing foundations of ProtoGenie stimulate a new kind of global research environment in which communities of researchers share research problems, designs, software, and results online. Cross-national interactions and communications are facilitated by the fact that special applications of the toolkit do not have to be created for non-English speaking countries.

8. Software Support for Programs

   Online access and ease of use support departmental and programmatic applications, such as campus computer support programs, scientific method curricula, programs for people with disabilities, global conference rooms, and online governance and virtual management.

DETAILS

Why Online?

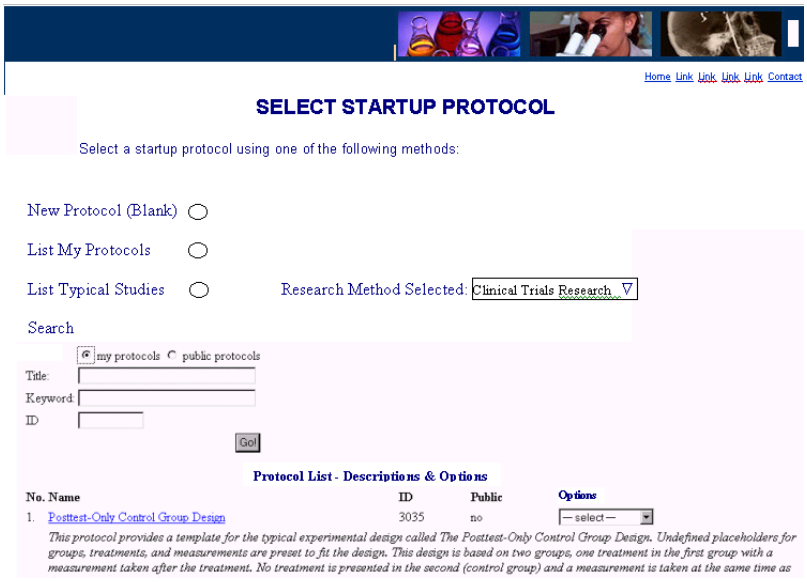
Given the familiar open-source and friendly development tools of Internet applications, online application enabled project researchers to design and write the software themselves, literally eliminating the communications gap between software engineers and researchers and dependence on highly specialized Microsoft development tools. The decision to build the system online also virtually guaranteed on-going development by researchers for researchers. Online application gives researchers universal access anywhere there is a computer and an Internet connection. Researchers and practitioners with or without programming skills can design and build their own research software and reuse it in new projects. They can conduct a study concurrently in many locations around the globe, tap vast pools of subjects in experiments online, conduct a field study or clinical trials using handheld devices, connect with specialized equipment & external software and support a science and methods curriculum or enrich a campus computer support program.

Other benefits of the online application include the liberation of researchers from expensive shrink-wrapped applications and irritating and distracting maintenance and upgrades. It provides universal access independent of equipment and operating systems. It provides a standard and familiar user interface consistent with the language of research. It provides for an integrated research-centered forum and an integrated help system. Finally, by the very nature of the Internet, implementation online fosters the decentralization of research and encourages small science as a remedy to "big science."

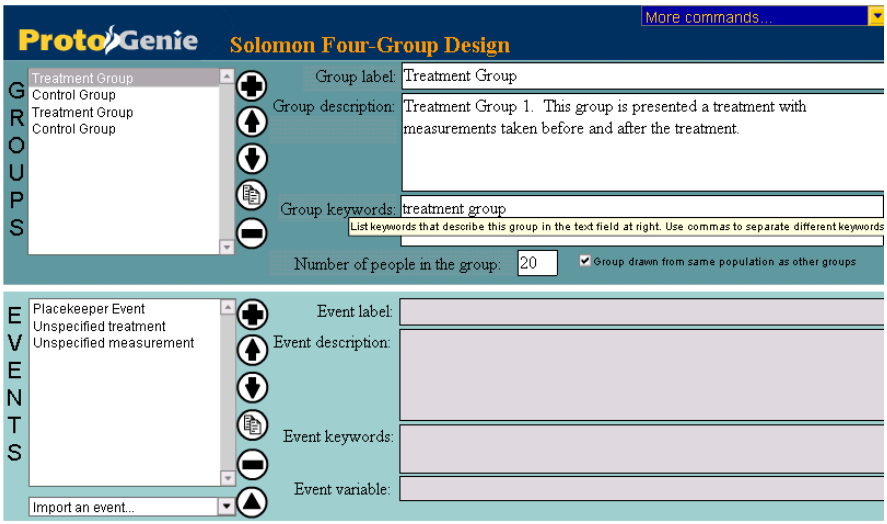
How Does ProtoGenie Work?

A registered ProtoGenie user connects with the Internet anywhere he/she has access to a computer with an Internet connection and opens the URL for the ProtoGenie Website (http://protogenie.com). The home page contains information about ProtoGenie, links to details about ProtoGenie, and a link to the ProtoGenie Editor, which is where research software is created and edited.

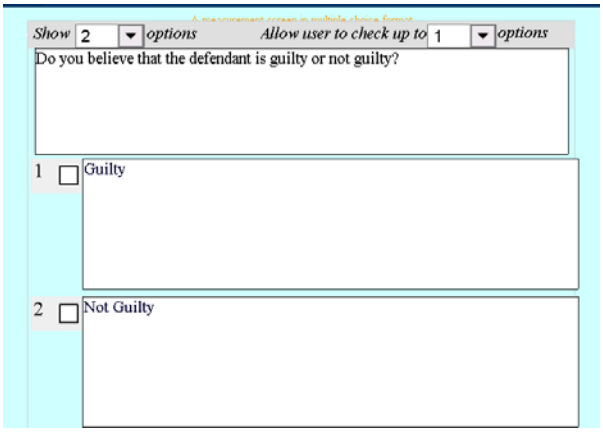
In the first page of the Editor, the user selects a research method closest to his/her study. Methods currently supported are classical & quasi-experimental research, clinical trials research, laboratory trials research, survey research, and observational research. This opens a page on which the user finds a suitable startup protocol from any of five sources, including a list of personal protocols, a list of typical designs (given the user's choice of method), a search of the ProtoGenie public protocols, or a blank protocol. See below.



Having selected a source, the user is given a list of protocols to browse or test. Each protocol in the list contains the options to view the protocol, execute it, edit it (if it belongs to the user), edit a copy of the protocol, and give or deny public access. From this browsing and testing process, the user selects the protocol that best fits the needs of his/her study. The ProtoGenie user then opens the selected protocol by selecting the Edit or Edit a Copy option accompanying the description of each protocol in the list. This brings up the ProtoGenie Editor page. See below.



Except for the case in which the user has decided to start with a Blank Protocol, the ProtoGenie Editor page contains a list of groups in the top frame and a list of events (intervention, measurement, and control) in the bottom frame for the group that is selected. Naturally, there are no intervention events in survey or observational studies. In the case of personal or public startup protocols, these groups and events have been previously defined, making the process of building new research software a process of editing definitions and adding or deleting groups and events to fit the study. In the case of typical design startup protocols, the number of groups and events and their sequencing is dictated by the (typical) design, but the groups and events themselves are completely undefined. In that case, the authoring process is one of defining "unspecified groups and events." Defining measurement events involves the choice of a measurement type (or "instrument). Instruments include multiple choice questions, true/false, short answer, fill in the blank, rank/order, rating scales, slider bars, matching, check box, dropdown options, list box, & timed-measurements. An example of a simple measurement instrument is as follows:



At any time during the building or modifying process the researcher can test the operation by executing the protocol. Events are executed in the order that they appear in the Events List starting with the first group in the list through the last. This order can be changed by moving groups and/or events up or down in their corresponding lists.

Alternative Interfaces

First-time users and those who prefer can choose an optional user interface that divides operations into research components (groups, interventions, measurements, control events, and sequencing) and displays them in a tabbed interface. In the tabbed interface, the ordering of events is done after the groups and events have been defined in a sequencing table in which rows are timelines for groups and columns are events. The two interfaces (single-page and tabbed) are completely interchangeable at anytime during the building process.

Data Collection and Formatting for Analysis

During the execution of a protocol, all data that are input by subjects, respondents, or researchers are stored in a form that is easily downloaded into popular spreadsheets and/or data analysis applications. After each session, the user can view a summary of the results of the session, including descriptive statistics if applicable. Results of studies also can be entered into the ProtoGenie database for use by other researchers and practitioners.

Using Protocols in Studies and Making Them Available to Others

Every new protocol can be launched anywhere there is a computer with an Internet connection (and the experimenter's permission) without time-consuming downloads. This means that ProtoGenie can support online studies or studies in many locations at the same time. After completion of a custom-built protocol, the developer can contribute his/her protocol to the ProtoGenie library of public protocols where researchers in the same field can adapt it for use in their own studies.

Specification of Research Methods Supported In First Release

Classical & Quasi-Experiments

Classical experiments seek to measure the causal effects of treatment variables on response variables through random assignment of subjects to experimental groups and through the manipulation of the treatment variables; sometimes referred to as "laboratory experiments" because of high degree of control over settings and are commonly used in psychology and related disciplines and in clinical settings, law and other professions. Studies that do not permit high levels of control are generally known as "Quasi-experiments" and are generally used in field settings such as schools and other institutions. Classical experiments create situations as close to real as possible. Quasi-experiments compensate for lack of controls through matching, placement and withdrawal of treatments, and statistical analysis. An example of an application of ProtoGenie for a classical experiment in vision science is the study of the effects of different types of room illumination and wall coloring on reading performance.

Clinical Trials

Clinical trials are studies that follow selected individuals forward in time from a pre-set baseline, some receiving an intervention and some no. Typically, such studies measure the effects of medical interventions, including therapeutic agents, devices, regimens, and procedures. They are most commonly used in medical, pharmaceutical, and public health research. A major part of the design of clinical trials is usually the provision of mechanisms and procedures for maximizing and assessing "compliance," as in taking a medication daily in the prescribed amount at the prescribed times. An example of an application of ProtoGenie in clinical trials in vision science is a test of the efficacy of sustained-release, intraocular implants that deliver ganciclovir in the treatment of cytomegalovirus retinitis in patients with the acquired immunodeficiency syndrome (AIDS). Typically, this study would involve one or more control groups that receive another intervention or a placebo.

Laboratory Trials

Laboratory trials typically involve repeated presentations of stimuli (interventions or treatments) and measurements (trials); such trials often use equivalent materials to control the effects of memorizing. Stimuli are often presented on visual and auditory devices and are commonly used in vision, cognitive, and human performance research. Laboratory trials are also used in materials research and testing. Examples include testing the effects of colored text and backgrounds on reading speed and comprehension and testing the effects of distractors on target detection and recognition. An industrial example might test the effects of variable temperatures on the properties of a material or product. An example of laboratory trials research in vision science might involve the repeated presentation of 19 smiling faces and 1 frowning face with random placement on a computer display with the objective of measuring the effects of distractors on the detection and location of an object in a visual space.

Survey Research

Survey research is the study of attitudes, beliefs, and behavior of people and their settings through questionnaires administered by mail, handouts, personal and, telephone interviews, and the Internet. Such studies range from one question polls to large-scale studies. Sometimes they employ panels and time samples. They are frequently used in national and local studies of political and economic attitudes and reported behavior. In surveys, there is no conscious attempt to intervene to determine causality. They are used to identify important variables, to increase understanding, and sometimes to promote a change through education. An example of an application of ProtoGenie in a survey in vision science is an online questionnaire for a sample of individuals who have been fitted with Irlen tinted lenses, which seeks to learn whether the lenses were used, how they were used, and what problems were encountered.

Observational Research

Observational research is the systematic, first-hand observation of some event in progress, such as a classroom, gang activity, legislative body, or discussion group, usually guided by a check list of anticipated events or phenomena and spaces for entering unanticipated events or phenomena as they occur. An example of an application of ProtoGenie in an observational study in vision science is a systematic recording of observations of accident avoidance behaviors and confrontations in a busy corridor at a convention for blind people.

Future Applications

As ProtoGenie evolves, it eventually will extend support to all empirical research, evaluation research, and practitioner support systems, such as diagnostic systems. In many cases, extending support only involves the development of collections of protocols that are representative of the field along with some changes in terminology. In other cases, extending support requires new features and options in the ProtoGenie Editor, which can be made with ProtoGenie's Webcentric and open source architecture. Support for empirical research methods will include archival research, industrial research, case studies, single subject research, longitudinal & cohort research. Evaluation research includes product and program evaluation. Decision support systems include process simulations, workflow systems, expert systems, and diagnostic systems. Also, ProtoGenie will be applied in organizations in departmental and programmatic ways, as for example, to support a campus social science computing laboratory.

ProtoGenie Challenge Projects

ProtoGenie is currently promoting "Challenge Projects" on campuses and elsewhere that involve the construction of protocol libraries and new features. To start things off, three interesting projects are suggested: product testing & evaluation with a focus on products for the disabled, the complex display generator for non-programmers, and clinical diagnosis with a focus on vision. These applications raise unique problems, many of which will be solved by students and other users with the assistance of ProtoGenie Staff.

Phase III Dissemination

Business Model

The business model for ProtoGenie dissemination is based on free memberships with free access to the program and free access to the source code for modifying copies of the application to fit local or highly specialized needs. In the future, modest fees of some kind may be introduced to support further development, maintenance, and special programs.

Nationwide Application

ProtoGenie is available to anyone with a computer and Internet access. At the present time, all a person needs to do is register and sign on. The URL is http://www.protogenie.com. New users are already trying it out in several places, including the College of Law, University of Arizona, Tucson, Arizona.

First Test Bed

The initial ProtoGenie test bed is at the School of Optometry, the University of California at Berkeley, under the direction of Dr. Scott Fitz, consultant and lead programmer of ProtoGenie on the Web and Dr. Ian Bailey, chief field consultant, in collaboration with Dr. Lawrence Boyd, Pasadero, Inc, Tempe, AZ

Plans for Expansion

Campus Computer Support Programs

Discussions are underway with the directors of the Information Technology program of the University of California to consider implementation of ProtoGenie in the Social Science Computing Laboratory (SSCL) and Computer-Assisted Survey Methods Program (CSM) at the

University of California at Berkeley. After this, opportunities will be pursued for implementing ProtoGenie at other major universities in their campus computer support programs and then at smaller education institutions, including high schools.

Departmental and Programmatic Applications

Given universal and free access along with universal application, individuals within disciplines, departments, and research programs will become interested in the possibilities of implementing a computer support network based on ProtoGenie. An example may be the Law Laboratory at the College of Law, University of Arizona, Tucson, Arizona. Early models will have worldwide exposure on the ProtoGenie Website.

Global Expansion

Online accessibility makes widespread use possible in other countries. It is assumed that successful models in various countries will be emulated in other countries.

Government Applications

We expect to publicize the cost-savings, wide utility, and easy access to ProtoGenie services in publications available to government research agencies and funding agencies so that they might adopt ProtoGenie, recommend its use, or bring it to the attention of researchers.

A Bonus From Technological Drift

ProtoGenie was first built as planned on a conventional C++ commercial application foundation. However, with the coming of age of the Internet, ProtoGenie was completely re-written by ProtoGenie staff researchers for implementation on the Internet. This resulted in a fully developed product of significant potential as an information systems development toolkit. This product was named "DynaGrapher." Examples of applications include workflow simulations, problem-solving systems, expert systems, diagnostic systems, selections systems, intake systems, and many other applications. Its unique features include modular component design and a real time events logger. The feature that distinguishes this product from all other process designers is its executable diagram user interface. In effect, you lay out a process in a work area, using components from a component bin, and what you see IS the program. Simply press RUN.

Details about DynaGrapher are available at its own website where there a free download of the software. This site is located at http://pasadero.com/dynagrapher/. It is available for use though not officially supported. Developers who are interested in using it for applications of their own are invited to contact us for licenses or proposals for collaborative development.

PUBLICATIONS

The ProtoGenie authoring toolkit for researchers is published on the Internet at http://protogenie.com. Membership and access to the toolkit is free.