DsTool:
A Dynamical System Toolkit with an Interactive Graphical Interface

Based on the program kaos written by S. Kim and J. Guckenheimer

User's Manual

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Chapter 1

Introduction

1.1 DsTool and Dynamical System Toolkits

A *dynamical system* is defined by a set of rules or transformations for determining how points in a multidimensional space move in time. Time may either be discrete or continuous. The traces of the points as they move in discrete or continuous time are called *trajectories* The goal of dynamical systems theory is to provide a comprehensive description of the geometric structures arising from these trajectories. In addition to elucidating the dynamics associated to an individual dynamical system, bifurcation theory may be used to describe how the dynamics of a system varies with changes in parameter values.

Interactive numerical and graphical exploration are important tools in dynamical systems research for several reasons:

- There is generally no way to obtain trajectory information other than by iteration or numerical integration;
- The geometric structures of a dynamical system are often intricate and extremely sensitive to changes in the system parameters, so that interactive computation and graphics have proved useful in interpreting their meaning;
- Exploration of a dynamical system often involves the generation of large quantities of data. Usually, only a small proportion of data must be saved, and typical computer facilities seldom allow for the indiscriminate storage of information. Therefore, it is important to find compact and efficient representations of a system's dynamics that can be easily retrieved.

Consequently, there is a critical need for computational environments that provide effective tools for exploring dynamical systems with minimal effort on the part of the user. Research that relies upon the investigation of dynamical systems would be greatly enhanced by a standard, uniform environment for the exploration of these systems with computers.

The explosion of the graphical computational capabilities of relatively inexpensive desktop computers in the past few years makes the development of such an environment both feasible and timely. This document describes an implementation of one such environment

for the Sun UNIX workstation. The *toolkit* that we describe is an efficient research tool that integrates a friendly graphical user interface, data management capabilities, a rich set of numerical algorithms together with the flexibility to add more algorithms and communicate data with other programs. The program, called *DsTool* (pronounced dee-ess-TOOL), has been implemented for use with the X Window system from MIT. DsTool is based upon the program kaos, written by S. Kim and J. Guckenheimer.

Chapter 2

Attributes of Interface Windows

2.1 Conventions

The DsTool toolkit was written to conform to the SUN *Open Look*© conventions whenever possible. For example, a button labeled with an inverted triangle means that activating the button opens a menu while a menu entry with trailing ellipses implies the entry will generate a pop-up window if selected. We will also use the Open Look nomenclature SELECT, ADJUST, and MENU when referencing the mouse buttons. (If your mouse has three buttons then these are usually the left, middle and right buttons, respectively.) In addition the following conventions and notation are used throughout:

Window title: The window title is the text located in the window header.

Function: A brief summary of the window's main purpose within DsTool.

Description: Instructions on how to open the window and a detailed account of the window's behavior when the user interacts with it.

Panel items: A complete listing of all items located on the window's control panel, along with a brief description of each item's characteristics. The terms used in this document are:

- Button: There are four types of buttons used in DsTool. A *command* button initiates an action. Some actions are potentially dangerous (e.g., writing data to a file which already exists) and so the action is accompanied by a *notifier* which requests confirmation. The second type of button used is the menu button which is a button with a label followed by an inverted triangle. A menu of options is available when MENU is selected while the pointer is on this button. A third type of button is a *window button* which consists of a label followed by ellipsis (...) marks. This button opens a pop-up window when selected. The last type of button is known as an *abbreviated menu button* and consists only of an inverted triangle. This item functions just like a menu button.

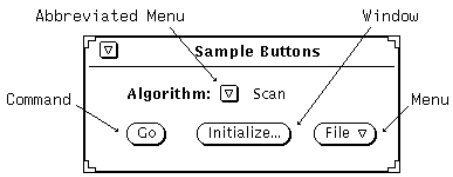
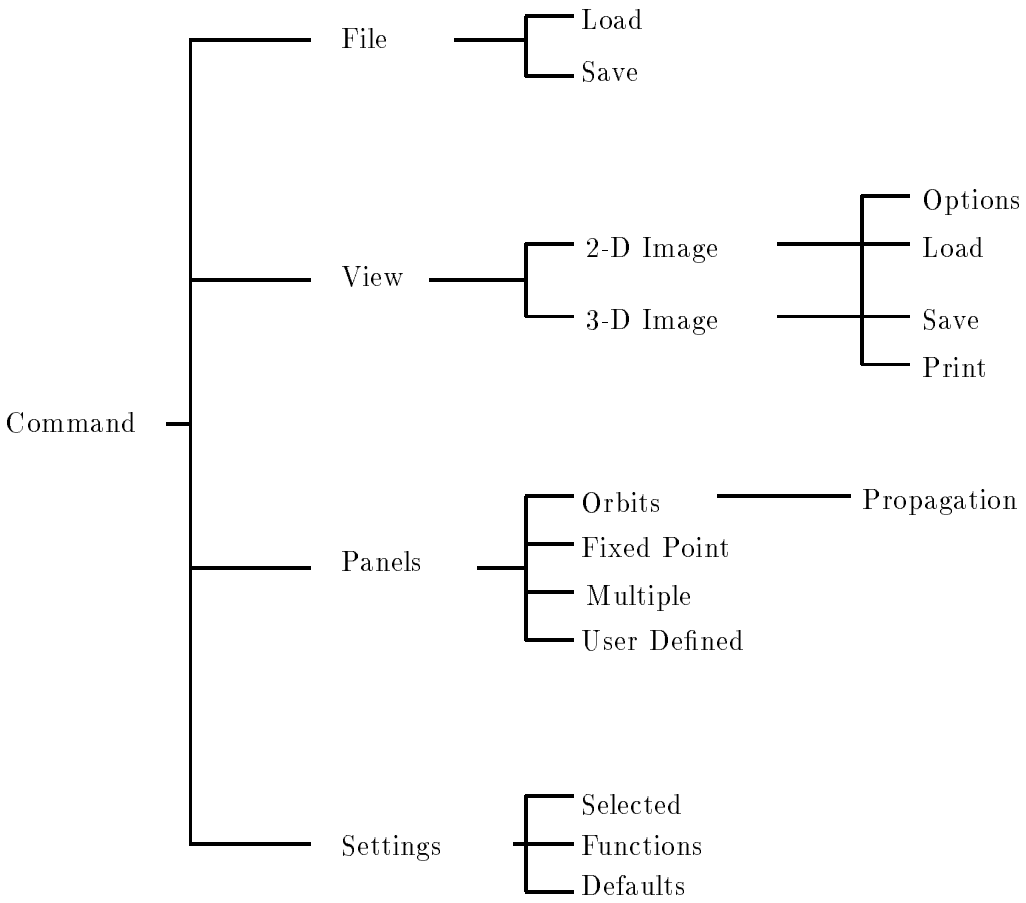


Figure 2.1: Four types of buttons.

- Text Fields: A text field is an area where numerical or alphabetic information may be stored and displayed. Most text fields are *read-write*, meaning that the user may input information into them, but some text fields are *read-only*. A text field which accepts only integer values is called a *numeric* field.
- Message: Similar to the text field is a message. The program uses messages to display information to the user. A message is always read-only.
- Settings: A setting is a list of choices. A *non-exclusive* setting presents options which may be chosen independently, such as selecting data to be saved into a file. An *exclusive* setting is a set of options which are mutually exclusive, such as the choices "on" and "off." A third type of setting is called a *stack* setting. It is related to the exclusive setting in that only one option may be selected from among the choices, but unlike the exclusive setting, not all options are displayed at one time. The currently selected option is displayed next to an abbreviated button; all options may be viewed by clicking the button with MENU.
- Text Pane: A text pane is a region in which the user may read, write, edit, and save text.
- Canvas Pane: A canvas pane is a region in which graphical information is displayed.


Command
File
Load
Save
View
2-D Image
3-D Image
Options
Load
Save
Print
Panels
Orbits
Propagation
Fixed Point
Multiple
User Defined
Settings
Selected
Functions
Defaults

2.2 The Command Window

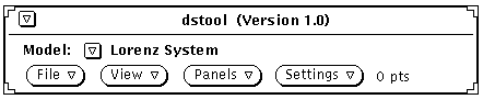


Figure 2.2: The Command Window.

Window title: DsTool

Function: The Command Window is the main control panel for the dynamical system toolkit.

Description: The Command Window is opened at start-up. The main function of this window is to allow the user to interact with the package through various panel items. Iconizing this window causes all other DsTool windows to disappear from view (including the icons of any windows owned by the package). The subsequent reopening of the package results in a return to the state the user was in before the package was iconized.

Panel items:

- Model stack setting: Allows the user to select a dynamical system to study.
- File menu button:

  Load...: Opens and brings to the foreground the Load Window.

  Save...: Opens and brings to the foreground the Save Window.
- View menu button:

  2-D View...: Opens a two dimensional view window.
- Panels menu button:

  Orbits...: Opens and brings to the foreground the Orbits Panel.

  Fixed Point...: Opens and brings to the foreground the Fixed Point Panel.

  Batch...: Opens and brings to the foreground the Batch Panel. *Not yet implemented.*

  Multiple...: Opens and brings to the foreground the Multiple Orbits Panel.

  User-Defined...: If the user has installed panels, they are opened and brought to the foreground by selecting the menu items appearing in this location. See the Reference Manual for more information on installing user-defined panels.
- Settings menu button:

  Selected...: Opens and brings to the foreground the Selected Point Window.

  Function...: Opens and brings to the foreground the Function Settings Window.

Defaults...: Opens and brings to the foreground the Defaults Settings Window.

- *n* pts message: The total number of data points (of all data types) currently stored in memory.

2.3 The Save Window

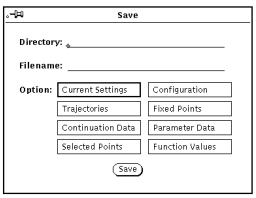


Figure 2.3: The Save Window.

Window title: Save

Function: This panel is used to control saving data to files.

Description: The Save Window is opened by selecting the Save option from the File menu button located in the Command Window. Selecting the Save command button initiates the save procedure.

Panel items:

- Directory read-write text field: Displays the currently selected directory to which DsTool will save data. The default is the current value of the unix environmental variable `DSTOOL_DATA_DIR`.
- Filename read-write text field: Displays the currently selected filename to which DsTool will save data. There is no default.
- Option non-exclusive selection:

  Current Settings: This is the default option. The current initial conditions, parameter values, and default settings are saved to the file specified in the Filename text field. Specifically, the data saved makes up the Orbits, Multiple Orbits, and Fixed Point panels, as well as the Selected Point and Default Settings Windows.

  Configuration: The positions and sizes of most DsTool windows and panels are saved to the data file specified in the Filename text field. With the exception of the Save and Load windows and user-defined panels, windows which can be chosen from the Command Window may have their sizes and positions saved. For each View Window that is open, the View Options (most of which are found on the View Options Panel) are also saved. View Options include the background color, colormap type, and horizontal and