METHOD AND APPARATUS FOR RECOGNIZING GESTURES ON A COMPUTER SYSTEM

BACKGROUND OF THE INVENTION

This invention relates generally to computer systems, and more particularly to graphical user interfaces for computer systems.

Graphical user interfaces or GUI are becoming increasingly popular with computer users. It is generally accepted that computers having graphical user interfaces are easier to use, and that it is quicker to learn an application program in a GUI environment than in a non-GUI environment.

A relatively new type of computer which is well suited for graphical user environments is the pen-based or pen-aware ("pen") computer system. A pen-based computer system is typically a small, hand-held computer where the primary method for inputting data includes a "pen" or stylus. A pen-aware computer system is one which has been modified to accept pen inputs in addition to traditional input methods. A pen computer system is often housed in a relatively flat enclosure, and has a dual-function display assembly which serves as both an input device and an output device. When operating as an input device, the display assembly senses the position of the tip of a stylus on the viewing screen and provides this positional information to the computer's central processing unit (CPU). Some display assemblies can also sense the pressure of the stylus on the screen to provide further information to the CPU. When operating as an output device, the display assembly presents computer-generated images on the screen.

The dual-function display assemblies of pen-based computer systems permit users to operate the computer as a computerized notepad. For example, graphical images can be input into the pen-based computer by merely moving the stylus across the surface of the screen. A stroke can be defined as the engagement of the screen with a stylus, the movement of the stylus across the screen (if any), and its subsequent disengagement from the screen. As the CPU senses the position and movement of the stylus, it generates a corresponding image on the screen to create the illusion that the stylus is drawing the image directly upon the screen, i.e. that the stylus is "inking" an image on the screen. With suitable recognition software, text and numeric information can also be entered into the pen-based computer system in a similar fashion. Besides serving as a notepad, pen-based computers can provide a number of useful functions, such as serving as an address book, an appointment calendar, a to-do list, etc.

A common feature of pen computers is the use of "gestures". Gestures are symbols entered on a screen of a pen computer by a pointing device that perform a specific function or command for the user. Gestures are entered on the screen by a user, recognized by the computer, and the corresponding function or command is then implemented. For example, a jagged line can be implemented as a "scrub" gesture. A user writes a jagged line over a preexisting object displayed on the screen. The computer recognizes the jagged line as a scrub gesture and implements the function of the gesture, which is to delete all objects which the scrub gesture overlays. Other gestures can include arrows or lines to change lowercase text to uppercase text (or vice versa), and a carat to insert text within a text object.

Gesture recognition of the prior art, however, does not address certain issues. The method used to recognize gestures in the prior art can be inefficient or sometimes unreliable. If a user enters a gesture that does not look very similar to the standardized gesture shape, then the gesture will not be recognized. What is needed is an efficient and reliable gesture recognizer that is more personalized to the user's handwriting.

SUMMARY OF THE INVENTION

The method and apparatus of the present invention provides a gesture recognition process which is particularly well adapted to the pen computer environment.

In a first method aspect of the invention, a stroke input by a user to the computer screen is smoothed by reducing the number of points that represent the stroke. It is then determined whether the smoothed stroke includes at least a predetermined minimum number of points. If so, the angles between adjacent segments of the smoothed stroke as well as their derivatives are calculated. The angles and the derivatives of the angles are used to determine whether the stroke substantially represents an ellipse.

The method preferably includes smoothing the stroke by calculating a position for a new point that is positioned between two adjacent points in the stroke that are separated by less than the threshold distance and replacing the two adjacent points with the new point. These steps are preferably repeated until all of the remaining points in the stroke are separated by at least the threshold distance. The method also preferably includes checking if points in a portion of the stroke are close enough to the opposite end point of the stroke; determining whether said stroke curves substantially in a single direction, and summing the derivatives of the angles and checking if said sum is within a predetermined range of values. If any one of these checks is false, then the stroke is not considered to be an ellipse gesture. The method also preferably includes selecting the ink object when the ink object is substantially overlapped by the smoothed stroke and the smoothed stroke substantially represents an ellipse. In an alternative embodiment, the method includes a step of determining whether the inputted stroke is part of a multiple stroke gesture, and, if so, adding the inputted stroke to stroke portions previously input by the user.

A computer system in accordance with the present invention includes a central processing unit (CPU), a screen coupled to the CPU, and a pointer device coupled to the CPU to provide user inputs which can be displayed on the screen. The apparatus further includes a mechanism for receiving a stroke input by a user onto the screen means by the pointer means, a mechanism for smoothing the stroke by reducing the number of points that represent the stroke, a mechanism for determining whether the smoothed stroke includes at least a predetermined minimum number of points, a mechanism for calculating angles and their derivatives between adjacent segments of the smoothed stroke, and a mechanism for determining whether said stroke substantially represents an ellipse utilizing said angles and said derivatives of said angles.

In a second method aspect of the invention, a stroke input by a user to the computer screen is processed to smooth the stroke. The smoothed stroke is then normalized and stored in a buffer. The normalized stroke is checked if it matches one of a plurality of gesture prototypes. When at least one gesture prototype matches the normalized stroke, the gesture represented by the best matched gesture prototype is selected to represent the stroke. The smoothing step preferably includes reducing a number of points that define said