touches applied when the table and/or monitor are shaking from moderate bumping, or from several rapidly delivered strong touches.

As before stated, it should be noted that analogous difficulties may arise in other force measuring applications, such as that of weighing objects on an insecure or moving support, or weighing in the presence of a large tare mass which is excited by rapid operation.

The invention therefore provides a new solution to this class of problems.

OBJECTS OF INVENTION

It is accordingly an object of the invention, therefore, to provide a new and improved method of and apparatus for measurement of forces that are immune to disturbing effects of an unsteady mounting or support for the force-measuring apparatus through canceling or elimination of errors caused by such effects in the force measurements.

It is a further object of the invention to provide such a novel method of and apparatus for measurement of forces that are immune to the disturbing effects of movement, in response to changes in the applied force, of the mass supported by the force-measuring apparatus, as well.

Another object is to provide these immunities in a manner that can be conveniently applied to a wide range of circumstances, with characteristics of support and of supported mass which are not beforehand known, but for which the force-measuring apparatus can be easily field-calibrated by the user.

Still another object is to provide an improved touch-input computer or related display employing touch force location, including externally to the display, that is rendered immune to inertial interference effects.

Other and further objects will be explained hereinafter and are more particularly delineated in the appended claims.

SUMMARY OF INVENTION

In summary, from one of its broader aspects, the invention embraces in a touch-input computer and related supported display employing touch force location measurements, a method of eliminating the errors that may be introduced into force and/or torque measurements by undesired inertial interference motions of one or more of the support, mechanical system of the display and/or force measuring apparatus itself, that comprises, sensing one or more components of force and/or torque applied to the display by touch forces to provide force and/or torque measurements uncorrected for inertial interference motion effects that may arise; sensing lineal and/or rotational acceleration of the display in response to such inertial interference motions; and correcting the uncorrected force and/or torque measurements in response to the acceleration sensing to reflect or achieve substantial elimination from the measurements of the effects of such inertial interference.

Other features of the invention and preferred and best mode designs are hereinafter set forth.

Underlying the invention, however, are three related aspects, corresponding to the above-stated objects.

1) Particular accelerometers are incorporated into the force-measuring device in sufficient number and manner to record all relevant degrees of freedom of motion of the support (if attached to the support side), or of the attachment to the unknown force (if attached to the measurement side). A typically different Linear combination of these accelerometer channels is added in turn to each channel of uncorrected force measurement, with coefficients of combination chosen such that the resulting sums reflect the desired force measurements, free of error, in the low frequency limit, or in the limit of an arbitrarily stiff connection to all of the supported mass, due to tilting or change of motion of the support.

2) In addition, or alternatively if desired, sets of correction channels are derived corresponding to time derivatives of the uncorrected force measurements, including typically at least the set of the second derivatives, but possibly also sets of one or more derivatives of other orders. A typically different linear combination chosen such that the resulting sums reflect the desired force measurements, free of error due to changing the supported mass, to the extent that the support itself does not change motion.

3) Coefficients of combination for correction channels are determined empirically, in situ. Such correction channels may comprise accelerometer readings, and/or time derivatives of various order of these or of the uncorrected force readings, and/or related quantities of similar value, such as quantities effectively approximating the preceding over a desired frequency range, or linear combinations of any measured data containing the desired acceleration and/or derivative data. The force-measuring device is installed into its normal operating context, which may vary considerably from installation to installation. To calibrate, data are then gathered in the same manner as for normal force measurement purposes, but while the applied unknown force is allowed to remain at zero, and then while the system is intentionally disturbed in various ways. The idea is to gather a reasonably rich collection of measurement sets from moments when forces caused by acceleration of the supported mass are the only ones applied to the measurement side of the device. Disturbances may consist of pushing or shaking the system support in differing directions and patterns while data are gathered and/or pushing or shaking the supported mass at different points and in differing directions; data being gathered after the disturbing force is removed. A correction matrix may now be found, by methods later described, which relates the data collected from the correction channels to that gathered from the uncorrected force channels. The elements of this matrix comprise the desired coefficients of combination to achieve the above-stated corrections.

The invention contemplates that any of these three independently novel aspects may be separately used, or that they may be used in various combinations. The particular preferred application and embodiment described herein benefits indeed from incorporating all three. In this manner, the method and apparatus of my said copending application is significantly improved to work accurately and reliably with a wide range of massive and softly supported computer display monitors. A simple one-time calibration procedure is performed at display installation time, requiring no equipment, and being effectable in less than one minute to complete. For installations that would otherwise be plagued by large inertial effects, the typical performance improvement achieved is a factor of about thirty times reduction in error of reported touch location.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings,

FIG. **1** of which is a side elevation showing an illustrative application in which the preferred embodiment supports a computer CRT display monitor for purposes of user touch location as described in my said copending patent application;