synchronous subset. It also passes on the combination of finger identities in the synchronous subset to the chord motion recognizer **18**.

[0109] The motion component extraction module **16** computes multiple degrees of freedom of control from individual finger motions during easily performable hand manipulations on the surface **2**, such as hand translations, hand rotation about the wrist, hand scaling by grasping with the fingers, and differential hand tilting.

[0110] The chord motion recognizer produces chord tap or motion events dependent upon both the synchronized finger subset identified by the synchronization detector **14** and on the direction and speed of motion extracted in **16**. These events are then posted to the host communication interface **20**.

[0111] The pen grip detection module **17** checks for specific arrangements of identified hand contacts which indicate the hand is configured as if gripping a pen. If such an arrangement is detected, it forwards the movements of the gripping fingers as inking events to the host communication interface **20**. These inking events can either lay digital ink on the host computer display for drawing or signature capture purposes, or they can be further interpreted by handwriting recognition software which is well known in the art. The detailed steps within each of the above modules will be further described later.

[0112] The host communication interface keeps events from both the typing recognizer **12** and chord motion recognizer **18** in a single temporally ordered queue and dispatches them to the host computer system **22**. The method of communication between the interface **20** and host computer system **22** can vary widely depending on the function and processing power of the host computer. In a preferred embodiment, the communication would take place over computer cables via industry standard protocols such as Apple Desktop Bus, PS/2 keyboard and mouse protocol for PCs, or Universal Serial Bus (USB). In alternative embodiments the software processing of modules **10-18** would be performed within the host computer **22**. The multi-touch surface apparatus would only contain enough hardware to scan the proximity sensor array **6**, form proximity images **8**, and compress and send them to the host computer over a wireless network. The host communication interface **20** would then play the role of device driver on the host computer, conveying results of the proximity image recognition process as input to other applications residing on the host computer system **22**.

[0113] In a preferred embodiment the host computer system outputs to a visual display device **24** so that the hands and fingers **4** can manipulate graphical objects on the display screen. However, in alternative embodiments the host computer might output to an audio display or control a machine such as a robot.

[0114] The term "proximity" will only be used in reference to the distance or pressure between a touch device such as a finger and the surface **2**, not in reference to the distance between adjacent fingers. "Horizontal" and "vertical" refer to x and y directional axes within the surface plane. Proximity measurements are then interpreted as pressure in a z axis normal to the surface. The direction "inner" means toward the thumb of a given hand, and the direction "outer" means towards the pinky finger of a given hand. For the purposes of this description, the thumb is considered a finger unless otherwise noted, but it does not count as a fingertip. "Contact" is used as a general term for a hand part when it touches the surface and appears in the current proximity image, and for the group and path data structures which represent it.

[0115] **FIG. 2** is a schematic diagram of a device that outputs a voltage **58** dependent on the proximity of a touch device **38** to a conductive sense electrode **33**. The proximity sensing device includes two electrical switching means **30** and **31** connected together in series having a common node **48**, an input node **46**, and an output node **45**. A thin dielectric material **32** covers the sensing electrode **33** that is electrically connected to the common node **48**. A power supply **34** providing an approximately constant voltage is connected between reference ground and the input node **46**. The two electrical switches **30** and **31** gate the flow of charge from the power supply **34** to an integrating capacitor **37**. The voltage across the integrating capacitor **37** is translated to another voltage **58** by a high-impedance voltage amplifier **35**. The plates of the integrating capacitor **37** can be discharged by closing electrical switch **36** until the voltage across the integrating capacitor **37** is near zero. The electrical switches **30** and **31** are opened and closed in sequence but are never closed at the same time, although they may be opened at the same time as shown in **FIG. 2**. Electrical switch **30** is referred to as the input switch; electrical switch **31** is referred to as the output switch; and, electrical switch **36** is referred to as the shorting switch.

[0116] The proximity sensing device shown in **FIG. 2** is operated by closing and opening the electrical switches **30**, **31**, and **36** in a particular sequence after which the voltage output from the amplifier **58**, which is dependent on the proximity of a touch device **38**, is recorded. Sensor operation begins with all switches in the open state as shown in **FIG. 2**. The shorting switch **36** is then closed for a sufficiently long time to reduce the charge residing on the integrating capacitor **37** to a low level. The shorting switch **37** is then opened. The input switch **30** is then closed thus allowing charge to flow between the power supply and the common node **48** until the voltage across the input switch **30** becomes zero. Charge Q will accumulate on the sensing electrode **33** according to

$$Q=V\ (e^*A)/D \quad (1)$$

[0117] where V is the voltage of the power supply **34**, e is the permittivity of the dielectric sensing electrode cover **32** and the air gap between the cover and the touch device **38**, D is the thickness of this dielectric region, and A is the overlap area of the touch device **38** and the sensing electrode **33**. Therefore, the amount of charge accumulating on the sensing electrode **33** will depend, among other things, on the area of overlap of the touch device **38** and the sensing electrode **33** and the distance between the touch device **38** and the sensing electrode **33**. The input switch **30** is opened after the voltage across it has become zero, or nearly so. Soon after input switch **30** is opened the output switch **31** is closed until the voltage across it is nearly zero. Closing the output switch **31** allows charge to flow between the sensing electrode **33** and the integrating capacitor **37** resulting in a voltage change across the integrating capacitor **37** according to:

$$\text{delta } V=(V-Vc)/(1+C^*D/e^*A) \quad (2)$$