

CLAIMS

1. A method for decreasing latency between an acquisition of touch data and processing of an associated rendering task in a touch sensitive device having a touch sensing system capable of producing touch data at a touch sampling rate and having a display system that displays frames at a periodic refresh rate, the frames reflecting input to the touch sensing system, the method comprising:

estimating at least one of (a) a period of time for sampling touch data from the touch sensing system, (b) a period of time for computing touch event data from sampled touch data, and (c) a period of time for rendering of a frame to a frame buffer;

determining a period of time T_c for (a) sampling touch data from the touch sensing system, (b) computing touch event data from sampled touch data, and (c) rendering of a frame to a frame buffer, based at least in part on the estimate;

determining a point in time T_r at which the display system will be refreshed from the frame buffer;

computing a sampling start time based at least in part upon T_r and T_c ;

initiating sampling of the touch sensing system to obtain sampled touch data at the sampling start time;

computing touch event data from the sampled touch data;

rendering a frame reflecting the touch event data to the frame buffer prior to the time T_r ;
and,

refreshing the display system from the frame buffer.

2. The method of claim 1, wherein the step of refreshing the display system from the frame buffer comprises swapping first and second buffers of a double buffer.

3. The method of claim 1, wherein the step of determining a period of time comprises measuring at least one of: (a) the period of time for sampling touch data from the touch sensing system, (b) the period of time for computing touch event data from sampled touch data, and (c) the period of time for rendering of a frame to the frame buffer.

4. The method of claim 1, wherein the step of determining a period of time comprises measuring a period of time previously required for sampling touch data from the touch sensing

system, computing touch event data from sampled touch data, and rendering a previous frame to the frame buffer.

5. The method of claim 1, wherein the step of determining a period of time comprises measuring the refresh rate of the display system.

6. The method of claim 1, wherein the step of determining a period of time is performed iteratively.

7. The method of claim 1, wherein the step of determining the point in time T_r is performed utilizing a timestamp and the refresh rate.

8. The method of claim 1, wherein the step of determining the period of time comprises determining a period of time *a priori*.

9. The method of claim 8, wherein the step of determining a period of time *a priori* comprises determining a period of time without utilizing a measurement.

10. The method of claim 1, wherein the period of time for rendering of a frame to a frame buffer comprises a period of time for completion of rendering of the frame and writing data for the frame to the frame buffer.

11. The method of claim 1, wherein commencement of rendering is delayed until a time which allows rendering to be completed and a rendered output ready in a predetermined period of time prior to the display system refresh.

12. A method for decreasing latency between an acquisition of touch data and processing of an associated rendering task in a touch sensitive device having a touch sensing system capable of producing touch data at a touch sampling rate and a display system that displays frames at a periodic refresh rate, the frames reflecting input to the touch sensing system, the method comprising:

determining a period of time T_c required to compute touch event data from sampled touch data and render a frame to a frame buffer;

determining a point in time T_r at which the display system will be refreshed from the frame buffer;

sampling the touch sensing system to create sampled touch data;

computing touch event data from the sampled touch data, the beginning of the computing step being delayed to occur at a point in time that is at least as early as $(T_r - T_c)$;

rendering a frame to the frame buffer prior to the point in time T_r ; and,

refreshing the display system from the frame buffer.

13. The method of claim 12, wherein the step of refreshing the display system from the frame buffer comprises swapping first and second buffers of a double buffer.

14. The method of claim 12, wherein the step of determining a period of time comprises measuring a period of time previously required for computing touch event data from sampled touch data.

15. The method of claim 12, wherein the step of determining a period of time comprises measuring the refresh rate of the display system.

16. The method of claim 12, wherein the step of determining a period of time is performed iteratively.

17. The method of claim 12, wherein the step of determining the point in time T_r is performed utilizing a timestamp and the refresh rate.

18. The method of claim 12, wherein the step of determining the period of time comprises determining a period of time *a priori*.

19. The method of claim 18, wherein the step of determining a period of time *a priori* comprises determining a period of time without utilizing a measurement.

20. The method of claim 12, wherein the period of time for rendering of a frame to a frame buffer comprises a period of time for completion of rendering of the frame and writing data for the frame to the frame buffer.

21. The method of claim 12, wherein commencement of rendering is delayed until a time which allows rendering to be completed and a rendered output ready in a predetermined period of time prior to the display system refresh.

22. A method for decreasing latency between an acquisition of touch data and processing of an associated rendering task in a touch sensitive device having

(a) a touch sensing system capable of producing touch data at a touch sampling rate and having a sampling sync, and

(b) a display system that displays frames at a periodic refresh rate having a refresh sync,

the method comprising:

commencing sampling of touch sensor output on a sampling sync and placing sampled output in a sampling buffer at a sampling rate;

commencing frame rendering to one of a plurality of display buffers on a refresh sync;

displaying on a touch screen display images corresponding to a rendered frame on a refresh sync;

determining a period of time T_c corresponding to an estimated time for collecting the output in the sampling buffer;

determining a period of time T_m corresponding to an estimated time for computing touch event data from collected output;

determining a period of time T_r corresponding to an estimated time for rendering of a frame corresponding to the touch event data;

computing a start time based upon the refresh sync, T_c , T_m and T_r ; and

initiating collecting the output in the sampling buffer at the start time; and thereafter computing touch event data from collected output and rendering of a frame corresponding to the touch event data.

23. The method of claim 22, wherein the step of determining a period of time T_c comprises measuring a period of time previously required for sampling touch data from the touch sensing system.

24. The method of claim 22, wherein the step of determining a period of time T_m comprises measuring a period of time previously required for computing touch event data from sampled touch data.

25. The method of claim 22, wherein the step of determining a period of time T_r comprises measuring a period of time previously required for rendering a previous frame to the frame buffer.

26. The method of claim 22, wherein at least one of the steps of determining the period of time T_c , determining the period of time T_m , or determining the period of time T_r comprises measuring the refresh rate of the display system.
27. The method of claim 22, wherein the step of determining a period of time is performed iteratively.
28. The method of claim 22, wherein the step of determining the point in time T_r is performed utilizing a timestamp and the refresh rate.
29. The method of claim 22, wherein at least one of the steps of determining a period of time comprises determining a period of time *a priori*.
30. The method of claim 29, wherein the step of determining a period of time *a priori* comprises determining a period of time without utilizing a measurement.
31. The method of claim 22, wherein the period of time for rendering of a frame comprises a period of time for completion of rendering of the frame and writing data for the frame to the frame buffer.
32. The method of claim 22, wherein commencement of rendering is delayed until a time which allows rendering to be completed and a rendered output ready in a predetermined period of time prior to the display system refresh.
33. A method for decreasing latency between generation of touch event data and display images corresponding thereto displayed on a display of a touch sensitive device having a touch sensing system, the method comprising:
- commencing sampling of touch sensor on a sampling sync signal occurring at a sampling rate, and thereafter computing touch event data based upon sampled touch data;
 - determining a period of time corresponding to an estimated time to perform a rendering;
 - computing a wake time based upon a refresh sync signal occurring at a periodic refresh rate and the determined period of time; and
 - delivering the touch event data to an application running on the touch sensitive device at the wake time, thereby causing the performing of a rendering;

displaying on a touch screen display images corresponding to the rendering on a refresh sync signal.

34. A method for reducing latency between an acquisition of touch data and processing of an associated rendering task in a touch sensitive device having a touch sensing system capable of producing touch data at a touch sampling rate and a display system that displays frames at a periodic refresh rate, the frames reflecting input to the touch sensing system, the method comprising:

estimating at least one of (a) a period of time for sampling touch data from the touch sensing system, (b) a period of time for computing touch event data from sampled touch data, and (c) a period of time for rendering of a frame to a frame buffer;

determining a period of time T_c for (a) sampling touch data from the touch sensing system, (b) computing touch event data from sampled touch data, and (c) rendering of a frame to a frame buffer, based at least in part on the estimate;

determining a point in time T_r at which the display system will be refreshed from the frame buffer;

computing a sampling start time based upon T_r and T_c ;

initiating the sampling of the touch sensing system to obtain sampled touch data at the sampling start time;

computing touch event data from the sampled touch data;

rendering a frame reflecting the touch event data to the frame buffer prior to the time T_r ; and,

refreshing the display system from the frame buffer.