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Method and apparatus for displaying trend data

Technical Field

The present invention relates to a method and apparatus for displaying trend data. It particularly relates to a method and apparatus for displaying digitally-obtained trend data on an electronic display device, or in some variants a printer.

Background

Paper charts are conventionally used to record trends. A paper chart typically uses a sheet of paper which is translated at a constant rate in a first direction, and an ink pen which moves in a second, transverse direction to draw a trace on the paper in response to measuring the value of a time-varying quantity. When the pen moves more quickly, the trace appears thinner and/or lighter. When the pen moves multiple times over a location, the trace appears thicker and/or darker. The width (whether thinner or thicker) and intensity (whether lighter or darker) on the paper trace thus give a user additional information on the rate of change and the frequency of occurrence of the measured data while the data value varies with time. This is especially useful when the time taken by typical variations in the quantity corresponds to a very small translational distance of the paper movement and there is little variation in the gradient of the trace from which to obtain rate and frequency information.

Digital charts have been implemented to store the measured data digitally and to avoid having to use consumable ink and paper. However, a digital chart display typically comprises for each "time slot" (i.e. range of times; thus, the period of measurement is



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partitioned into time slots) only a simple trace one or a few pixels wide interpolated between a previous value and a current value. A digital chart display is therefore unable to provide visual information beyond showing the extreme measured data values during the time slot.

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Summary

The invention aims to provide new and useful methods and systems for displaying data representing a quantity which varies over time.

- 10 In general terms, the present invention proposes that data values (representing the value of the quantity at respective times) are partitioned into time slots. For each time slot, an array of trend weights (numerical values) is defined. Each trend weight corresponds to a respective value which the quantity may take. The array of trend weights is updated based on the data values within the time slot. For example, for given pairs of data
- 15 values, the corresponding trend weights can be found, and these trend weights and the trend weights between them, can be increased. The amount of the increase may depend on the difference between the data values. An image is then presented in which at least one time slot corresponds to a column or row of pixels, and different portions of the column/row of pixels are displayed with a characteristic which depends on the
- 20 corresponding weight trends.

A first specific expression of the invention is an apparatus for displaying an image representing the time-variation of a quantity, the apparatus comprising:

a processor configured to receive a plurality of successive data values, each data value representing the value of the quantity at a corresponding time, the processor being configured, for each of a plurality of time slots, to generate a corresponding set of a plurality of trend weights, each trend weight corresponding to a respective possible

5 value of said quantity, by, for successive data values:

- (i) determining the time slot containing the time associated with that data value, and
- (ii) updating one or more elements of the corresponding set of trend weights; and

an output device configured for displaying, for at least one of said time slots, a respective trace composed of portions corresponding to said possible values taken by

10 said quantity, at least one characteristic of each portion of the trace depending upon the corresponding trend weight.

A second specific expression of the invention is a method for displaying an image representing the time-variation of a quantity, the method comprising:

15 receiving a plurality of successive data values, each data value representing the value of the quantity at a corresponding time;

generating, for each of a plurality of time slots, a corresponding set of a plurality of trend weights, each trend weight corresponding to a respective possible value of said quantity, by, for successive data values:

- 20 (i) determining the time slot containing the time associated with that data value, and
- (ii) updating one or more elements of the corresponding set of trend weights; and

displaying, for at least one of said time slots, a respective trace composed of portions corresponding to said possible values taken by said quantity, at least one characteristic of each portion of the trace depending upon the corresponding trend weight.

Brief Description of the Drawings

In order that the present invention may be fully understood and readily put into practical effect, an embodiment of the invention will now be described by way of non-limitative example, the description being with reference to the accompanying illustrative

5 drawings, in which:

Fig. 1(a) is a schematic representation of a plurality of data points in a single time slot;

Fig. 1(b) is a schematic representation of a trace composed of pixels on a 0-100% scale by an embodiment of the invention;

Fig. 2 is a schematic representation of an exemplary apparatus which is an embodiment
10 of the invention;

Fig. 3(a) to (d) are various stages of a data array used by the embodiment having elements that store updated trace values and trend weights in a first example;

Fig. 4(a) to (d) are various stages of a data array used by the embodiment having elements that store updated trace values and trend weights in a second example; and

15 Fig. 5 is a flowchart of an exemplary method used by the embodiment.

Detailed Description of the Preferred Embodiments

A method as outlined in Fig. 5 and an apparatus shown in Fig. 2 which are exemplary embodiments of the invention will now be described.

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The method and apparatus provide a digital trend display that gives information on the rate of change and/or the frequency of occurrence of the measured data comprising a plurality of data points while the data values vary with time. Fig. 1(a) shows an exemplary plurality of data points 0-10 in a single time slot. The digital trend data is

displayed by the embodiment as a trace 102 composed of a column (or in alternative embodiments, a row) of pixels 104 on a 0-100% scale 106, as shown in Fig. 1(b).

As shown in Fig. 2, the apparatus 11 comprises a data receiver 12 that is configured for
5 receiving a plurality of successive data points from a data source 14 (step 502, Fig. 7).
Each of the data points has a data value. The data source 14 may be a measuring system
that comprises at least one device that measures real-time data as analogue signals and
converts them to digital values. Alternatively, the data source 14 may be a digital
storage device containing previously measured data (historical data) that has been saved
10 for future playback.

If more than one data source 14 is provided, the data receiver 12 is configured to select
the data source 14 according to a user's choice. The data receiver 12 may also be
configured to obtain real-time data from the measuring system and store it as historical
15 data in an internal storage device 15 for further selection.

The apparatus 11 also comprises a processor 16 that is configured for receiving the
plurality of successive data points from the data receiver 12. From the data points, the
processor generates trace values and updates these to a data memory 18. The processor
20 also determines a time slot for each data value (step 504) and generates trend weights
(step 506) that affect how the trace 102 is displayed on a display 20.

A controller 22 may be provided to assign each of the plurality of data points to its
appropriate time slot. The controller 22 is preferably also configured to instruct the

- processor 16 to generate trace values and compute trend weights for batches of data points received on a per time slot basis, so that the trace 102 is updated on the display 20 at regular intervals, each interval reflecting the duration of a time slot. This may be achieved by the controller 22 keeping a count of time slots and checking if current data points received by the data receiver 12 are within a current time slot. If a data point is found to enter a new time slot, the controller 22 may instruct the processor 16 to process data points that have been buffered as belonging to the current time slot for output to the display 20.
- 10 The apparatus 11 may further comprise a configuration editor 24 to allow a user to enter pre-set trace values for specific ranges of differences in data values, to make colour intensity selections for specific ranges of trend weights, to specify the duration for a time slot and for data collection, and so on.
- 15 Details of how this is accomplished are given in the following examples.

Example 1

- This example describes how the frequency of occurrence of data values may be displayed. Fig. 3(a) shows a numerical data array 30 stored in the data memory 18 that is initially set to 0 for all elements in the array 30. The elements may be 8, 16 or 32 bit unsigned integers. The array 30 has a size that is preferably determined by how many pixels the 0-100% scale 106 (in Fig. 1) is composed of. Each element of the array 30 is associated with a corresponding pixel of the display.

For example, the 0-100% scale 106 may span 500 pixels, in which case the array 30 correspondingly comprises 500 elements. In this example, a data value of 0% on the scale 106 is thus associated with array element [0] while a data value of 100% on the scale 106 is associated with array element [499], there being a total of 500 elements in the array 30. Since the 0-100% scale 106 is linear, data values between 0% and 100% are proportionately associated with their respective array elements between element [0] and element [499].

Table 1 shows an exemplary plurality of data points received by the data receiver 12, each having a data value. Given a 0-100% pixel span of 500 pixels, the associated array element for each data value can be readily determined as the nearest integer, as given in Table 1.

Data Point #	Data Value (%)	Associated Array Element
1	0.6	[3]
2	1.0	[5]
3	2.0	[10]
4	0.4	[2]

Table 1

As the processor 16 receives the data points, it interpolates between successive data points and generates trace values for all the data values between successive data points. For example, when data points #1 and #2 are received by the processor 16, the processor 16 generates a default trace value of 1 for their associated array elements [3] and [5] as well as each of all the intervening array elements. The generated trace values are updated to the data memory 18, as shown in Fig. 3(b).

When data point #3 comes in, the processor 16 generates further trace values for all the data values associated with the elements between data point #2 and data point #3, these being all the elements from elements [5] to [10] respectively, as shown in Fig. 3(c).

- 5 Similarly, trace values are generated from the element associated with data point #3 to the element associated with data point #4 when data point #4 is received, i.e., from element [10] to element [2].

The processor 16 also computes a trend weight for each data value by summing up the
10 generated trace values for each data value. Fig. 3(d) shows the trend weight for the array element associated with each data value that has occurred between successive data points. As data points are received in succession, the trend weight correspondingly updates. Using a default trace value of 1, the trend weight is therefore an indication of the number of occurrences of a particular data value in the plurality of data points that
15 has been processed.

Example 2

This example describes how the rate of change data value may be displayed.

Prior to processing any data points, a user pre-sets certain trace values to be associated
20 with specific ranges of difference in data value between successive data points. An exemplary pre-set is given in Table 2.

Difference in Data Value (%)	Pre-Set Trace Value
< 2.5	5
2.5 – 10.0	3
> 10.0	1

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Table 2

Table 3 shows an exemplary plurality of data points received by the data receiver 12, together with their associated array elements when using a 500-pixel array 30 for representing the 0-100% scale 106.

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Data Point #	Data Value (%)	Associated Array Element	Difference in Data Value (%) w.r.t. Next Data Point	Associated Pre-Set Trace Value
1	0.6	[3]	0.4	5
2	1.0	[5]	4.0	3
3	5.0	[25]	15.0	1
4	20.0	[100]	-	-

Table 3

As the plurality of data points are received, the processor 16 calculates the difference in data value between successive data points, for all the data points. The calculated differences are shown in Table 3. By looking up the pre-set trace values associated with the difference in data value, the processor 16 generates an appropriate trace value for each data point and updates the data memory 18 accordingly.

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Fig. 4(a) shows all the array elements initially set to 0.

Fig. 4(b) shows the trace value generated when data points #1 and #2 are received. The elements from element [3] to [5] are updated with the trace value of 5, according to the

25 pre-set.

When data point #3 comes in, the processor 16 generates further pre-set trace values for all the data values associated with the elements between data point #2 and data point #3, these being all the elements from elements [5] to [25] respectively, as shown in Fig. 4(c). The pre-set trace value in this case is 3.

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Similarly, pre-set trace values are generated from the element associated with data point #3 to the element associated with data point #4 when data point #4 is received, i.e., from element [25] to element [100].

10 The processor 16 computes a trend weight for each data value by summing up the generated trace values for each data value. Fig. 4(d) shows the trend weight for each data value that has occurred between successive data points. The trend weight is therefore an indication of the cumulative rate of change between successive data points. In both examples, the display 20 uses 500 pixels to represent the 0-100% scale. The
15 trace is therefore always within the 500 pixels on the display. Each of the 500 pixels is associated with an array element having a trend weight, as computed by the processor. As data points are received in succession, the trend weight is correspondingly updated in the data memory 18.

20 Using a 24-bit colour display and by designating different colours for particular trend weights, the colour of the trace can be made to vary according to the trend weight for each associated pixel. Optionally, the “colours” differ in brightness level, rather than being different parts of the visual spectrum. For example, the display may be set to display a dark colour when the trend weight is greater than 5, and to display a light

colour when the trend weight is less than 3. In this way, a user can tell from the colour of the displayed trace 102 how frequently a data value has occurred in the plurality of data points, and/or the rate of change between successive data points. Table 4 shows the trend value and corresponding pixel colour for each element in the array 30 when this colour setting is used to display the resultant trace 102 for Example 2, as shown in Fig. 1(b).

Element []	Trend Weight	Trace Colour
0 – 2	0	-
3-4	5	Medium
5	8	Dark
6 – 24	3	Medium
25	4	Medium
26-100	1	Light
101-499	0	-

Table 4

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Fig. 1(a) shows a plurality of data points 0-10 comprised in a single time slot having a specific duration. The duration may be determined by a user. Depending on the duration of each time slot and the duration of a course of data collection in which the plurality of data points are obtained, the plurality of data points may be comprised in a single time slot, or may be spread out over a number of time slots, as assigned by the controller 22.

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On the display 20, a single time slot comprising a plurality of data points may be allocated a pixel width of one pixel, such that the trace 102 has a stationary time axis, as shown in Fig. 1(b). A time slot thus represents the minimum resolution for trend display.

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In an alternative embodiment, “effective width” of the trace 102 (that is, the width of the trace according to the perception of a user) may be varied by using pairs of data points of a given time slot to increase the corresponding range of trend weights of one or more adjacent time slots. For example, if a time slot with a trace 102 is one pixel
5 wide, and if the display is showing more than one time slot at once (successive time slots being displayed as adjacent columns/rows of pixels), the “effective width” of the trace 102 can be used to indicate that the quantity has dwelt for a long time in the region of a particular data value. In this way, a wider effective trace 102 at a particular value would mean that the measured quantity is dwelling at that particular value for a longer
10 time. This mimics the action of an ink pen on a paper where ink would soak into the paper and spread out as a broader trace if the pen was allowed to dwell on the paper.

In use, a user of the embodiments described above may change the definition of the time-slots. For example the user may configure the device to concentrate on a certain
15 selected period during which data is selected, and to define the time-slots as (e.g. equal) intervals during the selected period. This process may be repeated iteratively, and/or successively for multiple selected periods. Having generated a display of interest, a user may control the embodiment to print that display out on a printer configured to generate rows/columns of possible dots corresponding to the row/column arrangement of the
20 display.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made

without departing from the present invention. For example, both the colour and the width of the trace 102 may be varied for one set of data. The trace 102 may be displayed as a sequence of spots instead of as a line.

Claims

1. An apparatus for displaying an image representing the time-variation of a quantity, the apparatus comprising:
a processor configured to receive a plurality of successive data values, each data
5 value representing the value of the quantity at a corresponding time, the processor being configured, for each of a plurality of time slots, to generate a corresponding set of a plurality of trend weights, each trend weight corresponding to a respective possible value of said quantity, by, for successive data values:
10 (i) determining the time slot containing the time associated with that data value, and
(ii) updating one or more elements of the corresponding set of trend weights; and
an output device configured for displaying, for at least one of said time slots, a
15 respective trace composed of portions corresponding to said possible values taken by said quantity, at least one characteristic of each portion of the trace depending upon the corresponding trend weight.

2. An apparatus according to claim 1 in which said updating step (ii) comprises:
20 (a) deriving from each data value a corresponding member of the set of trend weights and,
(b) for successive pairs of data values corresponding to times within the same time slot, increasing the value of all the trend weights between the corresponding pair of derived trend weights.

3. An apparatus according to claim 2 in which, in step (b), the pairs of successive data values are used to obtain a trace value, each of the trend weights between the corresponding pair of derived trend weights being updated by the trace value.
- 5 4. An apparatus according to claim 3 in which generating the trace value comprises calculating a difference in data value between the pair of data points and looking up a trace value associated with the difference, the trace value being selected from pre-set trace values associated with specific ranges of differences.
- 10 5. An apparatus according to any one of the preceding claims further comprising a weight configuration editor configured for pre-setting at least one variable which determines the relationship between data values and said at least one characteristic.
- 15 6. An apparatus according to claim 5 when dependent on claim 4 in which the weight configuration editor is further configured for allowing a user to specify the pre-set trace values and the specific ranges of differences.
- 20 7. An apparatus according to any preceding claim further comprising a data memory configured for storing trend weights computed by the processor.
8. An apparatus according to claim 7 in which the output device is a display device configured to refer to the trend weight stored in the data memory and to display

the traces, different portions of the trace being displayed with a characteristic of the trace according to the trend weight.

9. An apparatus according to any preceding claim in which the at least one
5 characteristic is colour brightness.
10. An apparatus according to any preceding claim in which step (ii) comprises
updating one or more trend weights corresponding to at least one adjacent time
slot.
- 10
11. A method for displaying an image representing the time-variation of a quantity,
the method comprising:
receiving a plurality of successive data values, each data value representing the
value of the quantity at a corresponding time;
15 generating, for each of a plurality of time slots, a corresponding set of a plurality
of trend weights, each trend weight corresponding to a respective possible
value of said quantity, by, for successive data values:
(i) determining the time slot containing the time associated with that data value,
and
20 (ii) updating one or more elements of the corresponding set of trend weights;
and
displaying, for at least one of said time slots, a respective trace composed of
portions corresponding to said possible values taken by said quantity, at

least one characteristic of each portion of the trace depending upon the corresponding trend weight.

12. A method according to claim 11 in which said updating step (ii) comprises:

- 5 (a) deriving from each data value a corresponding member of the set of trend weights and,
- (b) for successive pairs of data values corresponding to times within the same time slot, increasing the value of all the trend weights between the corresponding pair of derived trend weights.

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13. A method according to claim 12 in which, in step (b), the pairs of successive data values are used to obtain a trace value, each of the trend weights between the corresponding pair of derived trend weights being updated by the trace value.

15 14. A method according to any one of claims 11 to 13 in which generating the trace value comprises calculating a difference in data value between the pair of data points and looking up a trace value associated with the difference, the trace value being selected from pre-set trace values associated with specific ranges of differences.

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15. A method according to any one of claims 11 to 14 further comprising pre-setting at least one variable which determines the relationship between data values and said at least one characteristic.

16. A method according to claim 14 further comprising specifying the pre-set trace values and the specific ranges of differences.
17. A method according to any one of claims 11 to 16 further comprising storing
5 trend weights computed by the processor in a data memory.
18. A method according to claim 17 in which displaying the trace comprises referring to the trend weight stored in the data memory, different portions of the trace being displayed with a characteristic of the trace according to the trend weight.
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19. An method according to any one of claims 11 to 18 in which the at least one characteristic is colour brightness.
20. An method according to any one of claims 11 to 19 in which step (ii) comprises
15 updating one or more trend weights corresponding to at least one adjacent time slot.