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Aker et al.

(54) SYSTEM AND METHOD FOR DETERMINING PATROL SPEED

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Publication Classification

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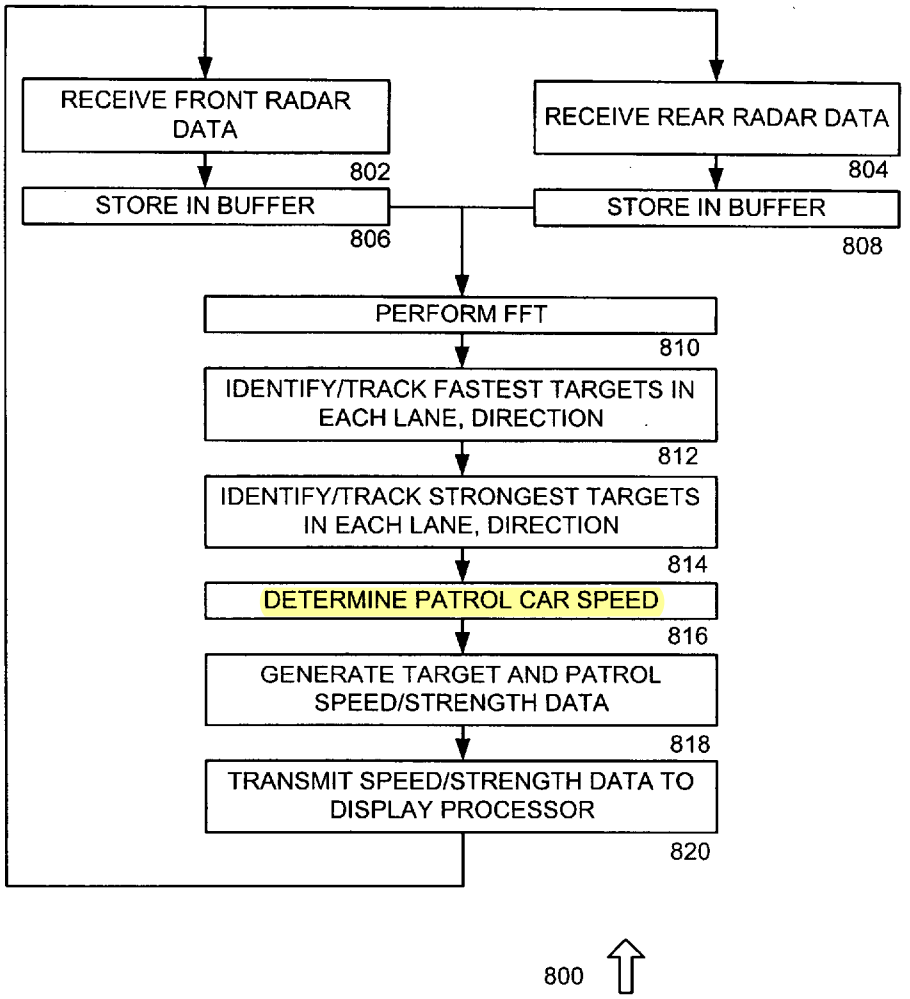
(57) **ABSTRACT**

A system for processing vehicle speed data for a vehicle is provided. The system includes a front antenna assembly of the vehicle generating a front digital signal, and a rear antenna assembly of the vehicle generating a rear digital signal. A fast Fourier transform system converts the front digital signal into front frequency shift data and the rear digital signal into rear frequency shift data. A patrol speed system matches the front frequency shift data and the rear frequency shift data and generates a vehicle speed for the vehicle.



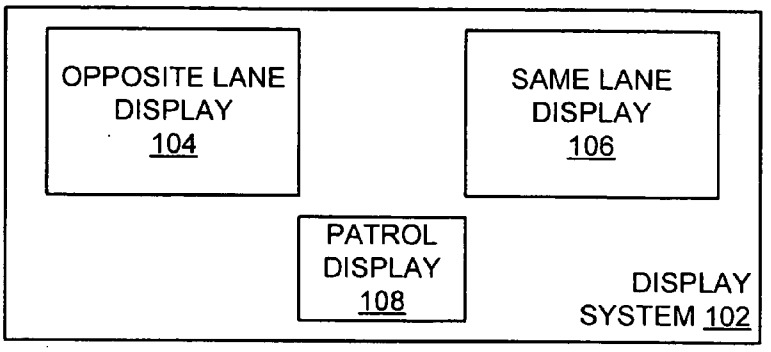


FIGURE 1 100

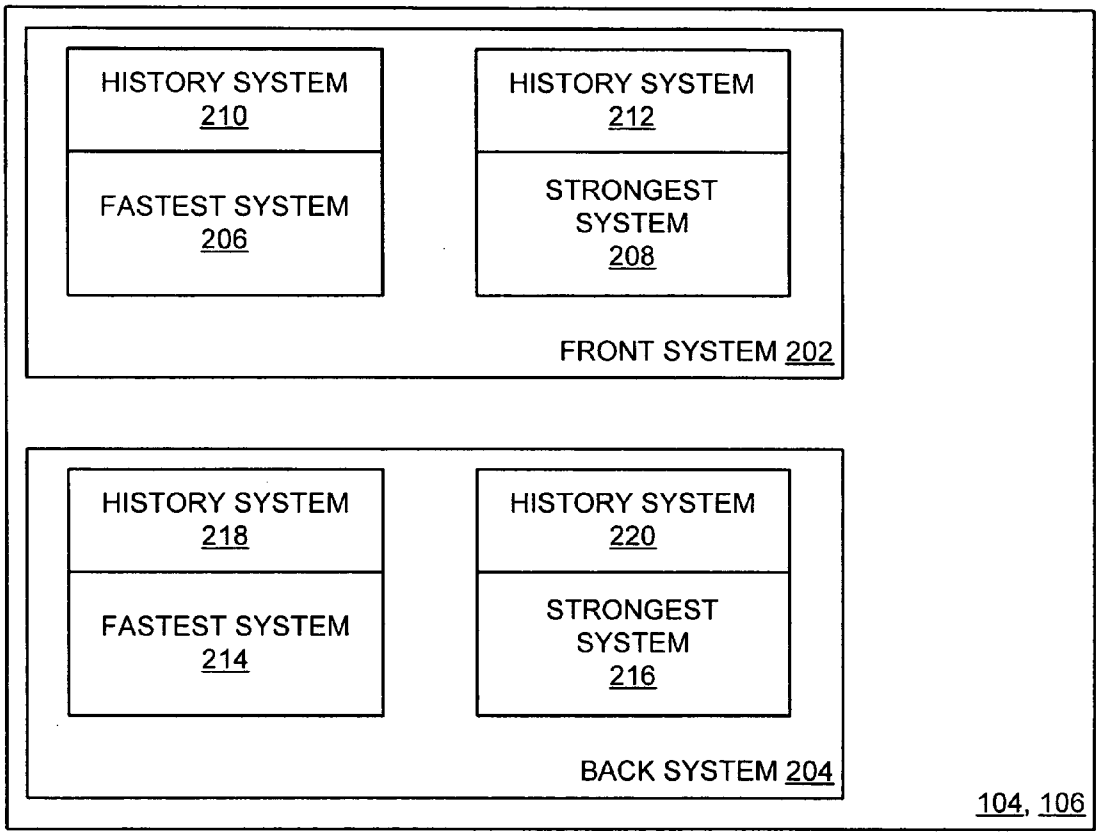


FIGURE 2 200

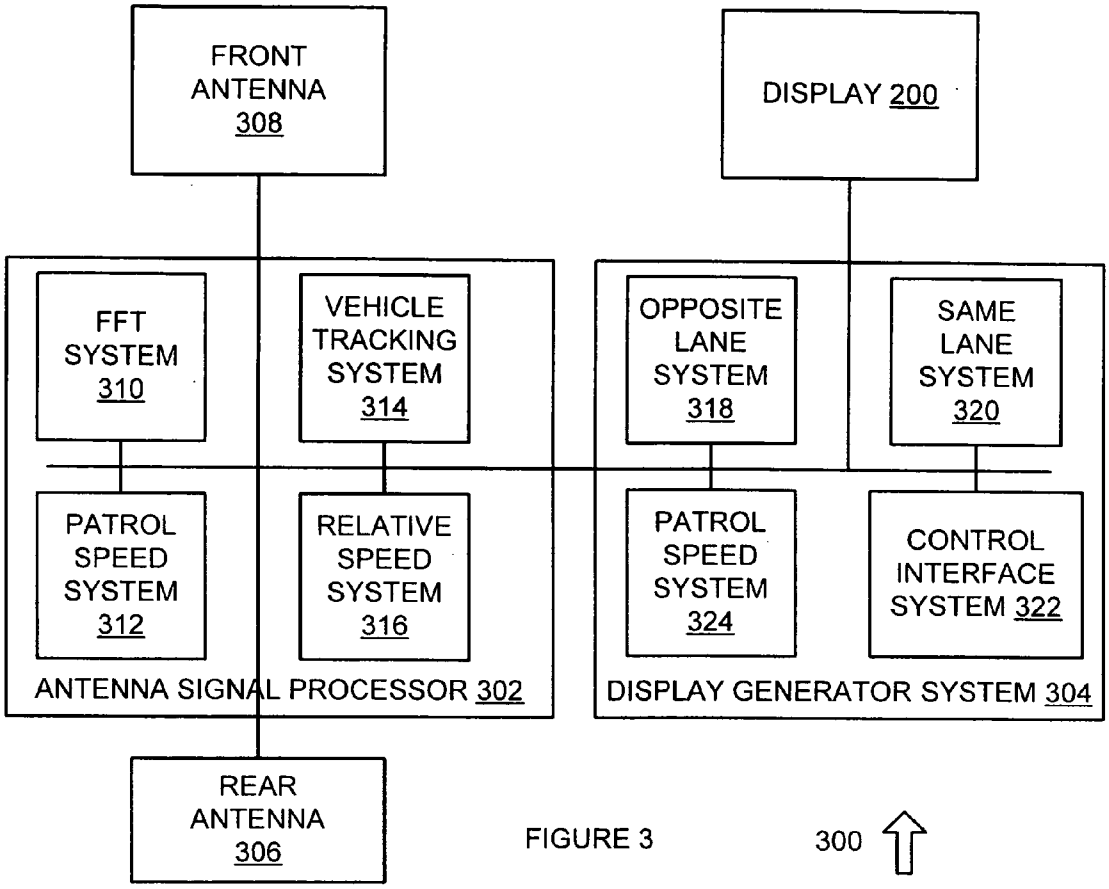


FIGURE 3

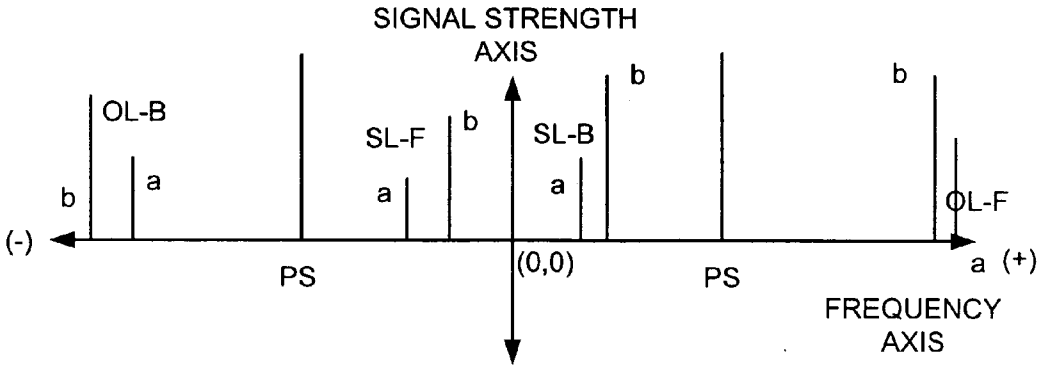


FIGURE 4 400

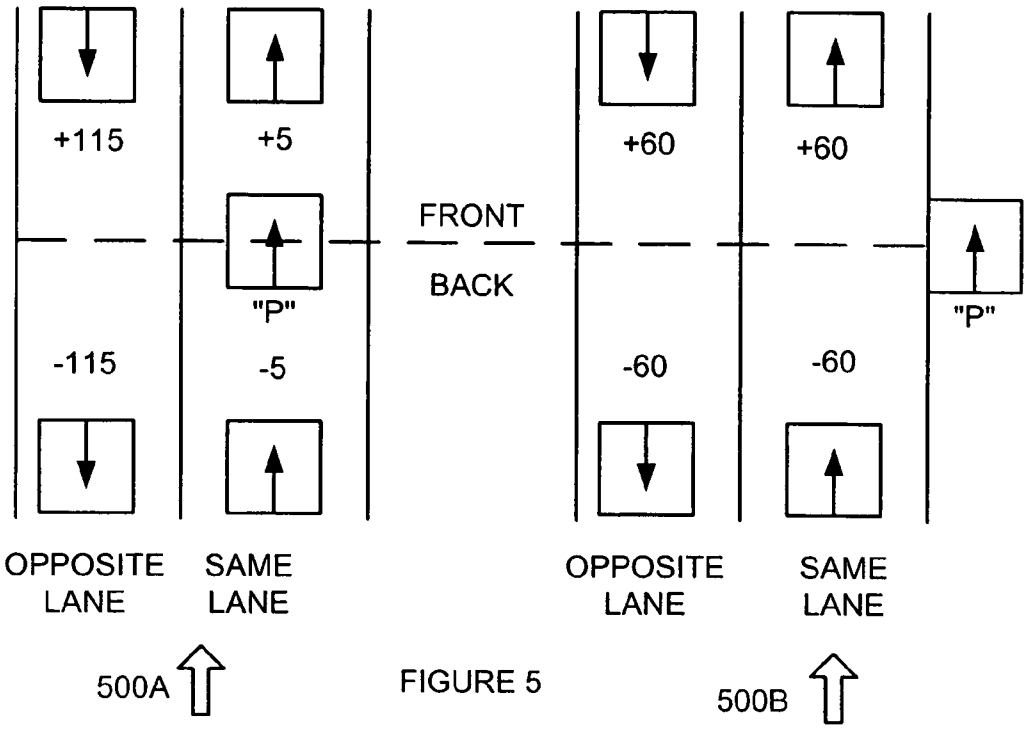


FIGURE 5

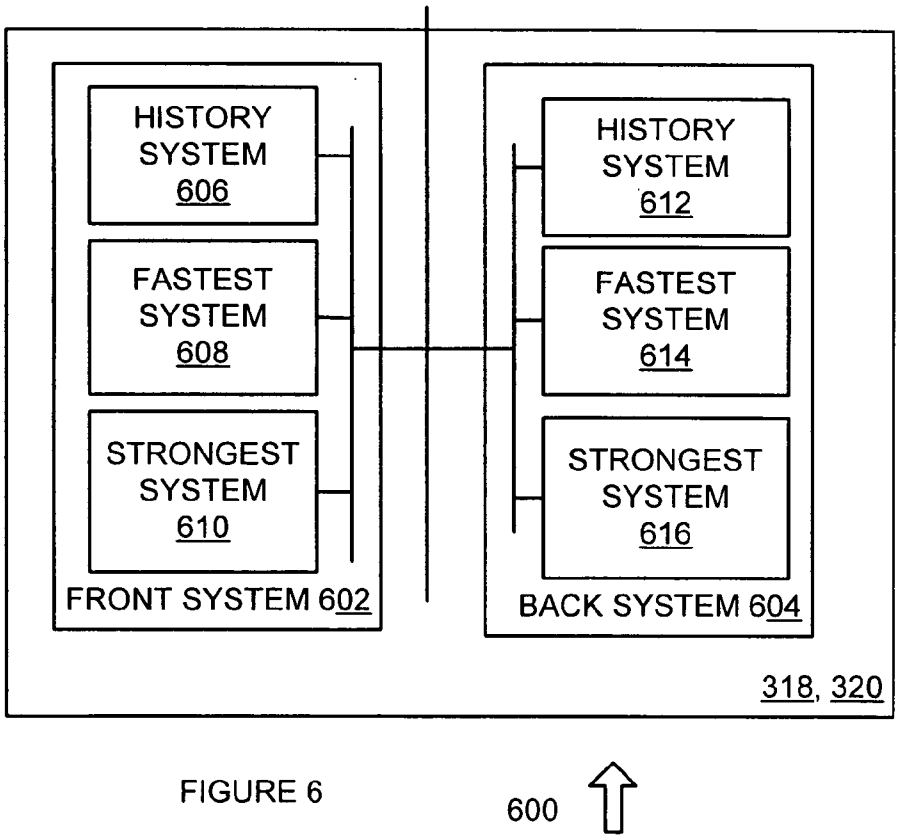


FIGURE 6

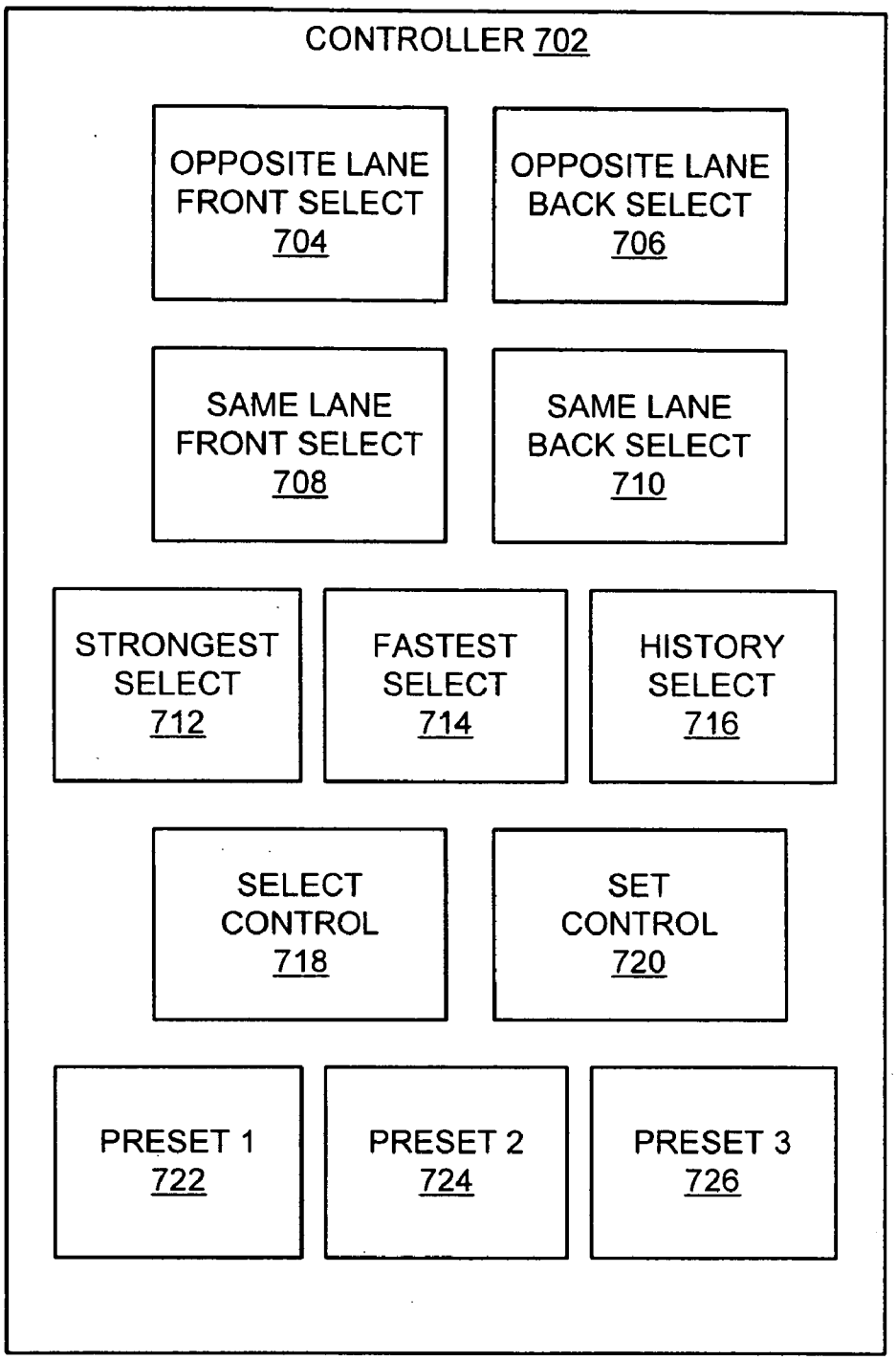

CONTROLLER 702
OPPOSITE LANE FRONT SELECT 704
OPPOSITE LANE BACK SELECT 706
SAME LANE FRONT SELECT 708
SAME LANE BACK SELECT 710
STRONGEST SELECT 712
FASTEST SELECT 714
HISTORY SELECT 716
SELECT CONTROL 718
SET CONTROL 720
PRESET 1 722
PRESET 2 724
PRESET 3 726

FIGURE 7

700

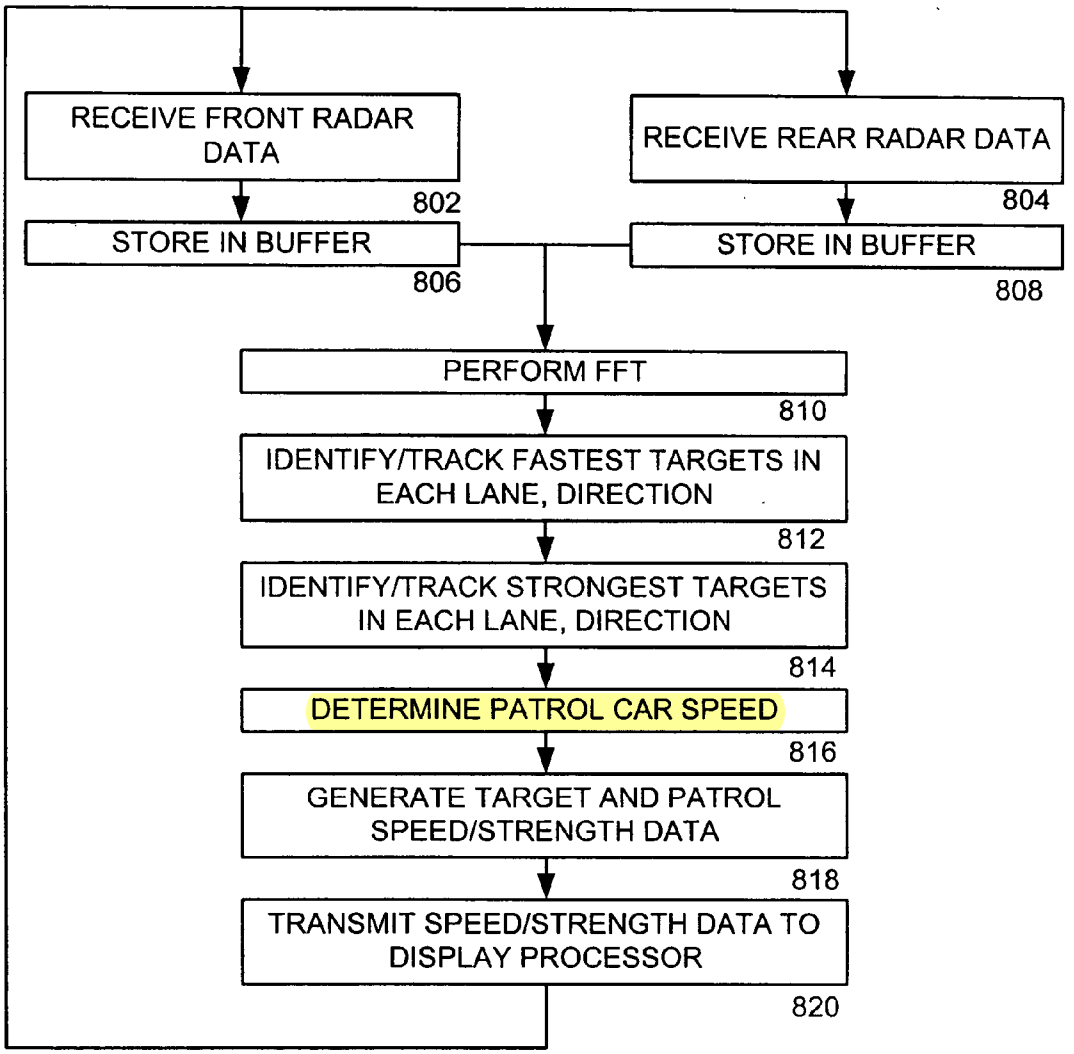

RECEIVE FRONT RADAR DATA
802
RECEIVE REAR RADAR DATA
804
STORE IN BUFFER
806
STORE IN BUFFER
808
PERFORM FFT
810
IDENTIFY/TRACK FASTEST TARGETS IN EACH LANE, DIRECTION
812
IDENTIFY/TRACK STRONGEST TARGETS IN EACH LANE, DIRECTION
814
DETERMINE PATROL CAR SPEED
816
GENERATE TARGET AND PATROL SPEED/STRENGTH DATA
818
TRANSMIT SPEED/STRENGTH DATA TO DISPLAY PROCESSOR
820

FIGURE 8

800

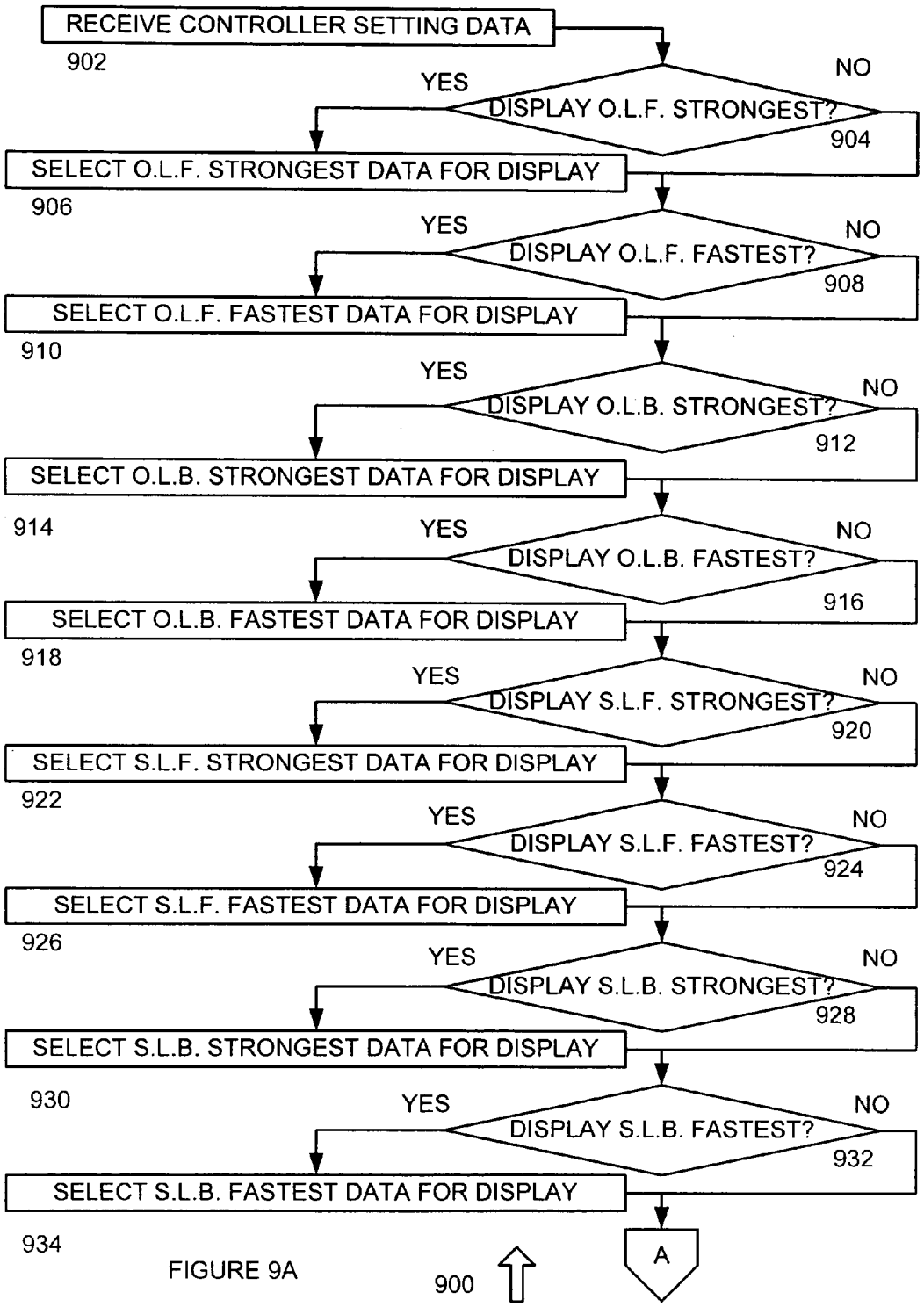
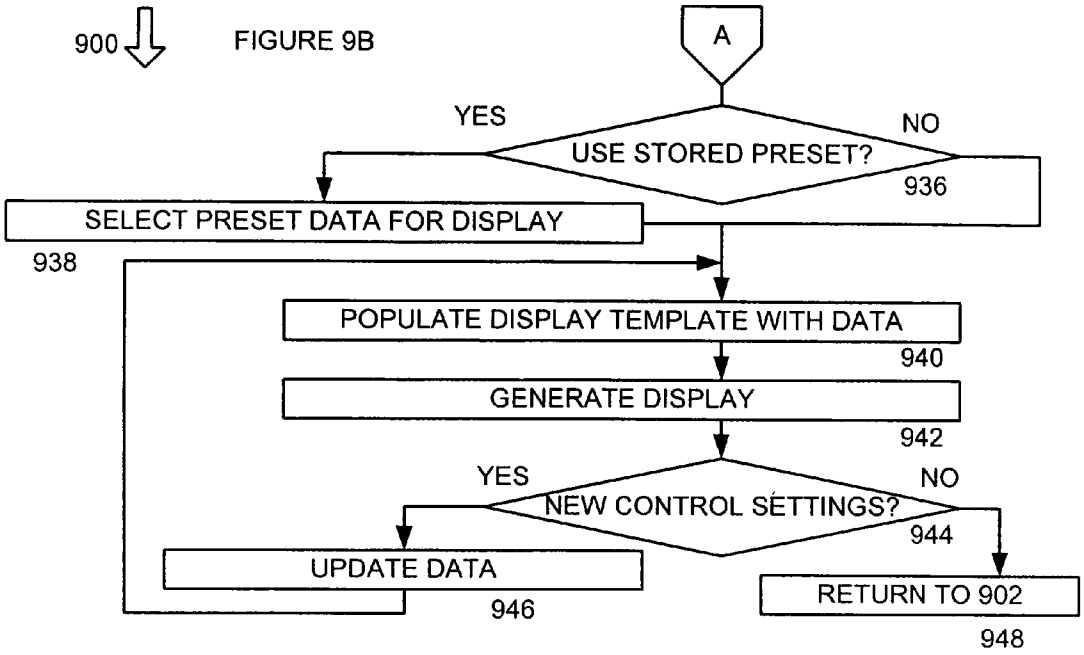

RECEIVE CONTROLLER SETTING DATA
902
DISPLAY O.L.F. STRONGEST?
904
YES
NO
SELECT O.L.F. STRONGEST DATA FOR DISPLAY
906
DISPLAY O.L.F. FASTEST?
908
YES
NO
SELECT O.L.F. FASTEST DATA FOR DISPLAY
910
DISPLAY O.L.B. STRONGEST?
912
YES
NO
SELECT O.L.B. STRONGEST DATA FOR DISPLAY
914
DISPLAY O.L.B. FASTEST?
916
YES
NO
SELECT O.L.B. FASTEST DATA FOR DISPLAY
918
DISPLAY S.L.F. STRONGEST?
920
YES
NO
SELECT S.L.F. STRONGEST DATA FOR DISPLAY
922
DISPLAY S.L.F. FASTEST?
924
YES
NO
SELECT S.L.F. FASTEST DATA FOR DISPLAY
926
DISPLAY S.L.B. STRONGEST?
928
YES
NO
SELECT S.L.B. STRONGEST DATA FOR DISPLAY
930
DISPLAY S.L.B. FASTEST?
932
YES
NO
SELECT S.L.B. FASTEST DATA FOR DISPLAY
934
A
900

FIGURE 9A


900
FIGURE 9B
A
YES
NO
USE STORED PRESET?
936
SELECT PRESET DATA FOR DISPLAY
938
POPULATE DISPLAY TEMPLATE WITH DATA
940
GENERATE DISPLAY
942
YES
NO
NEW CONTROL SETTINGS?
944
UPDATE DATA
946
RETURN TO 902
948

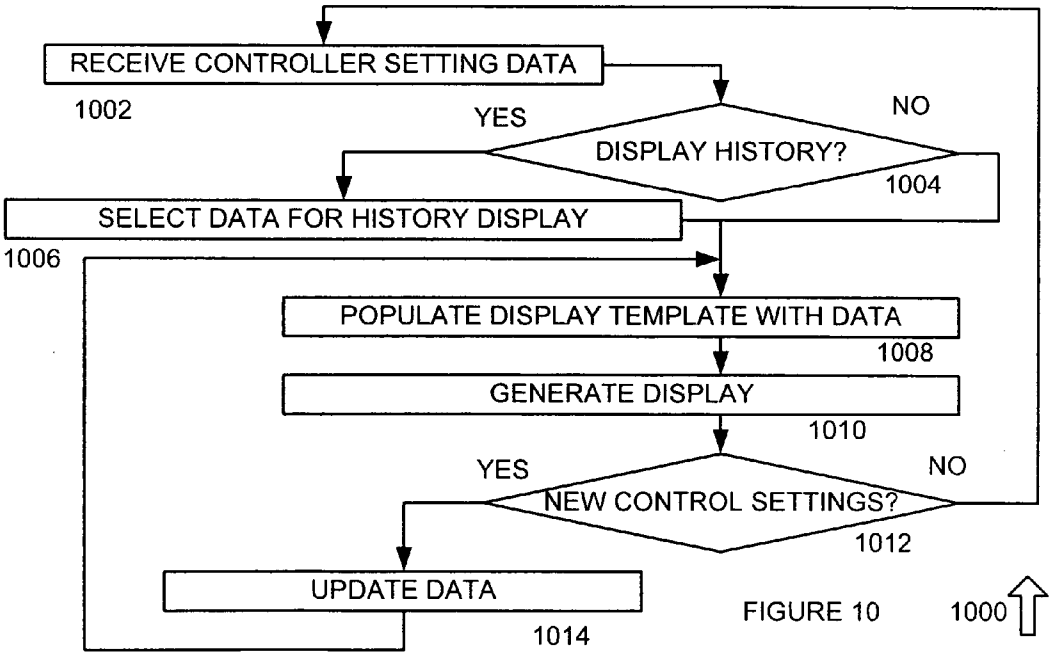
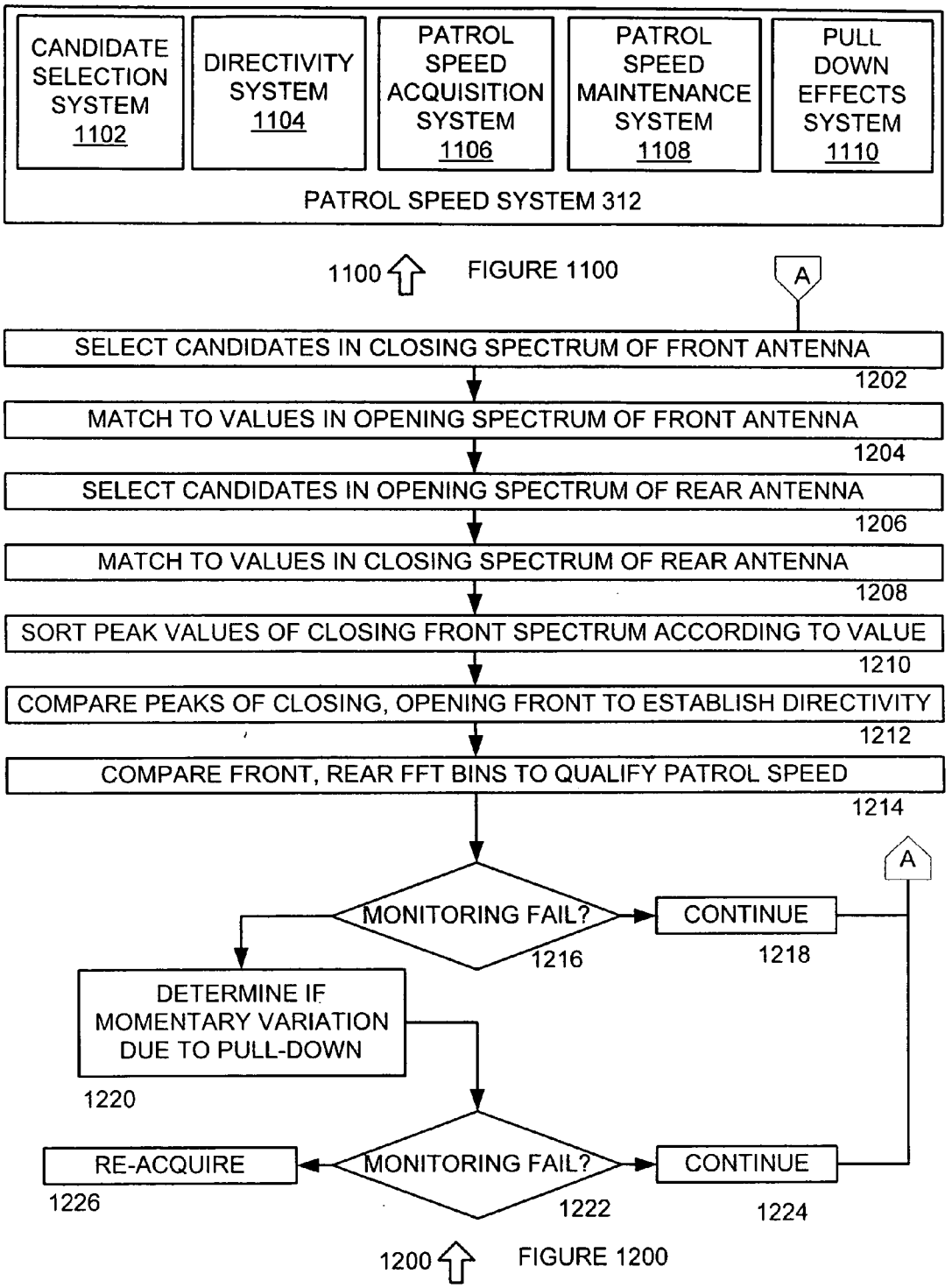

RECEIVE CONTROLLER SETTING DATA
1002
YES
NO
DISPLAY HISTORY?
1004
SELECT DATA FOR HISTORY DISPLAY
1006
POPULATE DISPLAY TEMPLATE WITH DATA
1008
GENERATE DISPLAY
1010
YES
NO
NEW CONTROL SETTINGS?
1012
UPDATE DATA
1014
1000

FIGURE 10


CANDIDATE SELECTION SYSTEM 1102
DIRECTIVITY SYSTEM 1104
PATROL SPEED ACQUISITION SYSTEM 1106
PATROL SPEED MAINTENANCE SYSTEM 1108
PULL DOWN EFFECTS SYSTEM 1110
PATROL SPEED SYSTEM 312
1100
FIGURE 1100
A
SELECT CANDIDATES IN CLOSING SPECTRUM OF FRONT ANTENNA
1202
MATCH TO VALUES IN OPENING SPECTRUM OF FRONT ANTENNA
1204
SELECT CANDIDATES IN OPENING SPECTRUM OF REAR ANTENNA
1206
MATCH TO VALUES IN CLOSING SPECTRUM OF REAR ANTENNA
1208
SORT PEAK VALUES OF CLOSING FRONT SPECTRUM ACCORDING TO VALUE
1210
COMPARE PEAKS OF CLOSING, OPENING FRONT TO ESTABLISH DIRECTIVITY
1212
COMPARE FRONT, REAR FFT BINS TO QUALIFY PATROL SPEED
1214
A
MONITORING FAIL?
1216
CONTINUE
1218
DETERMINE IF MOMENTARY VARIATION DUE TO PULL-DOWN
1220
RE-ACQUIRE
1226
MONITORING FAIL?
1222
CONTINUE
1224
1200
FIGURE 1200

SYSTEM AND METHOD FOR DETERMINING PATROL SPEED

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This invention is a continuation-in-part of U.S. application Ser. No. 09/930,866, entitled "System and Method for Processing Radar Data," filed on Aug. 16, 2001, which has issued as U.S. Pat. No. 6,580,386, and U.S. application Ser. No. 10/452,110, entitled "System and Method for Processing Radar Data," filed on Jun. 2, 2003, which is currently pending and which is hereby incorporated by reference for all purposes.

FIELD OF THE INVENTION

[0002] The present invention pertains to the field of speed detection radar systems. More specifically, the invention relates to a system and method for processing and displaying radar data that allows radar data from more than one antenna to be used to determine the patrol car speed.

BACKGROUND OF THE INVENTION

[0003] Systems for detecting and displaying radar data are known in the art. For example, U.S. Pat. No. 5,691,724, "A Police Traffic Radar Using FFT Processing to find Fastest Target," issued to Aker et al ("Aker") discloses a speed detecting radar system that is used to determine the speed of vehicles. Aker describes the use of digital signal processing that includes fast Fourier transform (FFT) processing of the reflected radar signal to determine the speed of one or more target vehicles.

[0004] One of the characteristics of many prior art radar speed detection systems is that they present data in non-flexible formats. The level of training and familiarity with radar speed detection equipment varies among police officers and other authorized users. Because police departments typically purchase standardized equipment, they purchase equipment that has essentially the same format. Furthermore, limitations on processor speed and the limited operating environment in which available displays can operate limit both the amount of data that can be processed by a speed detecting radar and the ability to display that data in a flexible manner, such as by using a video display terminal.

SUMMARY OF THE INVENTION

[0005] In accordance with the present invention, a system and method for processing and displaying radar data are presented that improve upon prior techniques of processing and displaying radar data.

[0006] In particular, a system and method for processing and displaying radar data are provided that allow radar data for vehicles travelling in two or more different directions relative to an observation point to be processed and displayed to a user in a user-selectable format.

[0007] In accordance with an exemplary embodiment of the present invention, a system for processing vehicle speed data for a vehicle is provided. The system includes a front antenna assembly of the vehicle generating a front digital signal, and a rear antenna assembly of the vehicle generating a rear digital signal. A fast Fourier transform system converts the front digital signal into front frequency shift data and the rear digital signal into rear frequency shift data. A patrol speed system matches the front frequency shift data and the rear frequency shift data and generates a vehicle speed for the vehicle.

[0008] Embodiments of the present invention provide many important technical advantages. One advantage of an embodiment of the present invention is a system and method for determining patrol speed that uses signals from a front radar antenna and a rear radar antenna to generate the patrol speed. In this exemplary embodiment, it is possible to generate an accurate estimate of the patrol car speed without the need for additional equipment.

[0009] Those skilled in the art will further appreciate the advantages and superior features of the invention together with other important aspects thereof on reading the detailed description that follows in conjunction with the drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0010] **FIG. 1** is a diagram of a system for displaying multi-lane radar data in accordance with an exemplary embodiment of the present invention;

[0011] **FIG. 2** is a diagram of a system for displaying radar speed data in accordance with an exemplary embodiment of the present invention;

[0012] **FIG. 3** is a diagram of a system for processing and displaying radar data in accordance with an exemplary embodiment of the present invention;

[0013] **FIG. 4** is a diagram of a signal strength indicator display showing frequency domain components of the radar signal received from two or more antennas, in accordance with an exemplary embodiment of the present invention;

[0014] **FIG. 5** shows relative vehicular speeds for understanding concepts of the present invention;

[0015] **FIG. 6** is a diagram of a system for generating display data in accordance with an exemplary embodiment of the present invention;

[0016] **FIG. 7** is a remote control for providing control data to a radar speed detector system in accordance with an exemplary embodiment of the present invention;

[0017] **FIG. 8** is a flowchart of a method for processing radar data from two or more antennas in accordance with an exemplary embodiment of the present invention;

[0018] **FIG. 9** is a flowchart of a method for allowing the user to configure a radar data display in accordance with an exemplary embodiment of the present invention;

[0019] **FIG. 10** is a flowchart of a method for selecting the historical display of data in accordance with an exemplary embodiment of the present invention;

[0020] **FIG. 11** is a diagram of a system for determining patrol car speed in accordance with an exemplary embodiment of the present invention.

[0021] **FIG. 12** is a diagram of a method for determining patrol car speed in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] In the description that follows, like parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawing figures are not necessarily to scale, and certain components can be shown in generalized or schematic form and identified by commercial designations in the interest of clarity and conciseness.

[0023] **FIG. 1** is a diagram of a system **100** for displaying radar data in accordance with an exemplary embodiment of the present invention. System **100** allows speed and signal strength data for vehicles traveling in different lanes or in different directions relative to the direction of travel of the patrol vehicle to be displayed on a single display.

[0024] System **100** includes display system **102**, opposite lane display **104**, same lane display **106**, and patrol display **108**, each of which are visual displays generated for viewing by an operator in an automobile or other suitable vehicles. In one exemplary embodiment, system **100** can be implemented using an Optrex F-51136 graphic liquid crystal display (LCD), available from Optrex America Inc. of Plymouth, Mich. Likewise, system **100** can be implemented using a suitable combination of light emitting diodes (LEDs), or other displays that can operate over a temperature range of −30° C.-85° C. and in vehicular environments.

[0025] System **100** can also include one or more software systems operating on a suitable processor that generates display data, touch-sensitive control interface data, and other suitable data, such as a Motorola MC68336GCFT20 microprocessor or other suitable processors. As used herein, a software system can include one or more objects, agents, threads, line of code, subroutines, separate software applications, two or more lines of code or other suitable software structures operating in two or more separate software applications, on two or more different processors, or other suitable software architectures. In one exemplary embodiment, a software system can include one or more lines of code or other suitable software structures operating in a general purpose software application, such as an operating system, and one or more lines of code or other suitable software structures operating in a specific purpose software application.

[0026] Opposite lane display **104** generates a display showing the relative signal strength, a fastest target, historical data, and other suitable data for opposite lane vehicular traffic. In one exemplary embodiment, opposite lane display **104** can include a display for the speed of the vehicle with a strongest signal, a display for the vehicle having a fastest speed, historical data for either or both vehicles, and other suitable data for the opposite lane oncoming vehicular traffic. Likewise, opposite lane display **104** can include similar data for the opposite lane traffic after it has passed the radar observation point, such as a patrol vehicle, from the rear. In this manner, opposite lane display **104** can allow the operator of a patrol vehicle to view the speed of a vehicle having a strongest signal, a fastest vehicle, and historical data for both vehicles for opposite lane traffic in front of and to the rear of the patrol vehicle.

[0027] Same lane display **106** generates a display showing the relative signal strength, fastest target, historical data, and other suitable data for same lane vehicular traffic. In one exemplary embodiment, same lane display **106** can include a display for the speed of the vehicle with a strongest signal, a display for the vehicle having a fastest speed, historical data for either or both vehicles, and other suitable data for vehicular traffic in the same lane that is in front of the radar observation point, such as a patrol vehicle. Likewise, same lane display **106** can include similar data for the same lane traffic to the rear of the radar observation point. In this manner, same lane display **106** can allow the operator of a patrol vehicle to view the speed of the vehicle having a strongest signal, a fastest vehicle, and historical data for both vehicles for same lane traffic in front of and to the rear of the patrol vehicle.

[0028] Patrol display **108** receives patrol vehicle speed data and generates a reference speed display. Patrol display **108** can receive speedometer data, background radar data, or other suitable data that has been converted into a patrol vehicle speed indicator data signal, and generates a numerical display for viewing by the operator of system **100**.

[0029] In one exemplary embodiment for a moving patrol car, the operator can use radar data from one antenna (either front or rear) without the requirement that the other antenna be operating or present. In this embodiment, the display can include opposite lane display **104** and same lane display **106** at the same time for that referenced direction.

[0030] In another exemplary embodiment, opposite lane display **104**, same lane display **106**, and patrol display **108** can be configured so as to respond to touch sensitive controls, such as by using an Optrex F-51136 graphic LCD or other suitable devices that support the generation of touch sensitive displays. In this exemplary embodiment, when the operator touches part of display system **102**, the coordinates of the location that the operator touched are converted into control data and are transmitted to a controller (such as a TI ADS 7842 Touch Screen Controller or other suitable systems or devices) that uses the control data to modify the display. In this manner, the operator can indicate that oncoming or receding traffic in either the opposite lane display **104** or same lane display **106** should be turned on or turned off, moved to a new location, locked, unlocked, or that other suitable actions should be taken. Likewise, the size or location of numerical speed displays for vehicles having a strongest signal or a fastest speed can be modified, such as by "dragging" the display to a desired location, "dragging" the borders of the display to change the size of the display, by using menu-driven selection processes that allow the user to configure the display into one or more predetermined templates, or in other suitable manners.

[0031] Likewise, system **100** can be implemented using fixed display elements, such as LEDs, so that any modifications to the display system **102** can be made by setting control data to turn LEDs on or off. In this exemplary embodiment, the display features of display system **102** cannot be moved relative to each other, such as by "dragging" or other suitable functions. Likewise, modifications to the display must be made within the framework of the fixed display elements. In this exemplary embodiment, the display can be configured to show a predetermined number of vehicles, such as:

[0032] 1. The speed of the vehicle having a strongest signal and the speed of the vehicle having a fastest speed,

with additional indicators showing whether each vehicle is in the same lane or an opposite lane, and whether the vehicle is in front of or behind the reference point (total of two vehicles maximum).

[0033] 2. The speed of the vehicle having a strongest signal and the speed of the vehicle having a fastest speed in each lane, with one additional indicator showing whether the vehicle is in front of or behind the reference point (total of four vehicles maximum).

[0034] 3. The speed of the vehicle having a strongest signal and the speed of the vehicle having a fastest speed in front and in back, with one additional indicator showing whether the vehicle is in the same lane or the opposite lane (total of four vehicles maximum).

[0035] 4. The speed of the vehicle having a strongest signal and the speed of the vehicle having a fastest speed in each lane and both in front of and behind the reference point (total of eight vehicles maximum).

[0036] In this exemplary embodiment, additional controls can also be provided, such as a feature that locks the display to show a selected vehicle's speed, a control that turns off a display that is not presently of interest to an operator, or other suitable controls.

[0037] In operation, system **100** allows an operator of a speed detecting radar system to view speed indication data for vehicles in two or more separate directions relative to a reference point. System **100** can also allow the operator of a speed detecting radar to configure the display to meet current patrol conditions, so as to remove unnecessary data from the display and to facilitate the ease with which an operator can confirm observations of persons exceeding speed limits.

[0038] **FIG. 2** is a diagram of a system **200** for displaying radar speed data in accordance with an exemplary embodiment of the present invention. System **200** allows an operator to select the display of speed data for up to eight vehicles in a simple and easily understood manner so as to facilitate the monitoring of traffic speeds and conditions by the operator.

[0039] System **200** includes either or both of opposite lane display **104** or same lane display **106**, which can each include front system **202** and back system **204**. Each of front system **202** and back system **204** further includes fastest system **206** and **214**, and strongest system **208** and **216**, respectively. Likewise, each of fastest system **206**, fastest system **214**, strongest system **208**, and strongest system **216**, can have a corresponding history system **210**, **218**, **212**, and **220**, respectively.

[0040] Any of the subsystems of system **200** can be turned on or off by an operator to increase or decrease the amount of data being provided to the operator, such as to accommodate current patrol conditions. In one exemplary embodiment, history systems **210**, **212**, **218**, and **220** can be omitted, such that only fastest systems **206** and **214** and strongest systems **208** and **216** are available. In another exemplary embodiment, a single indicator can be used that allows only one of fastest system **206** and **214** to be displayed and only one of strongest systems **208** and **216** to be displayed, where the operator can select for each system to display data for vehicles either in the front or in the back. In this exemplary embodiment, the operator could elect to view the speed of the vehicle providing a strongest signal from both the front and the back system, the speed of a fastest vehicle from the front and the back system, the speed of a fastest vehicle from the front and the speed of the vehicle having a strongest signal from the rear, or other suitable combinations of speed data. For the following 8 vehicle classes for type of vehicle and direction relative to the radar observation point, any suitable combination of classes 1 through 8 can be used in conjunction with display system **102** and system **200**:

[0041] 1. Same lane, front, speed of vehicle with a strongest signal.

[0042] 2. Same lane, rear, speed of vehicle with a strongest signal.

[0043] 3. Opposite lane, front, speed of vehicle with a strongest signal.

[0044] 4. Opposite lane, rear, speed of vehicle with a strongest signal.

[0045] 5. Same lane, front, speed of vehicle with a fastest speed.

[0046] 6. Same lane, rear, speed of vehicle with a fastest speed.

[0047] 7. Opposite lane, front, speed of vehicle with a fastest speed.

[0048] 8. Opposite lane, rear, speed of vehicle with a fastest speed.

[0049] Using these indicators, the following combinations could be used to display the speed of vehicular traffic in either the front or rear of the observation point, and in either the same lane or the opposite lane as the observation point: any 1 of the 8 classes of vehicles (8 combinations); any 2 of the 8 classes of vehicles (28 combinations); any 3 of the 8 classes of vehicles (56 combinations); any 4 of the 8 classes of vehicles (70 combinations); any 5 of the 8 classes of vehicles (56 combinations); any 6 of the 8 classes of vehicles (28 combinations); any 7 of the 8 classes vehicles (8 combinations); and all 8 of the 8 classes of vehicles (1 combination).

[0050] Likewise, system **200** can allow an operator to see additional data in response to touch sensitive controls or other suitable controls. For example, an operator can configure system **200** to display speeds by using touch sensitive control areas on the display, such as where the display initially shows all available fields in a setup mode, and the operator turns fields off by touching them. Likewise, a pull-down menu, a remote controller or other suitable controls can be used to allow the operator to select fields for viewing.

[0051] In operation, system **200** receives vehicle speed data and generates user-readable display data for vehicles travelling in two or more different directions relative to a radar observation point. System **200** allows an operator to flexibly display as few as one and as many as eight different signals in a single display. System **200** thus allows an operator to configure a display in response to changing patrol conditions, to match operator presets, or for other suitable purposes.

[0052] **FIG. 3** is a diagram of a system **300** for processing and displaying radar data in accordance with an exemplary embodiment of the present invention. System **300** allows a fast Fourier transform to be performed on antenna data from two or more antennas, and further allows display data to be generated that allows the radar data to be easily tracked by an operator.

[0053] System **300** includes antenna signal processor **302**, which can be implemented in hardware, software, or a suitable combination of hardware and software, and which can be one or more software systems operating on a Motorola 56307 DSP and associated digital signal processing equipment. In one exemplary embodiment, antenna signal processor **302** can be configured with associated devices in a manner similar to counting/display unit 12 of U.S. Pat. No. 5,691,724, which is hereby expressly incorporated by reference for all purposes. The digital signal processor of antenna signal processor **302** performs simultaneous digital data processing for both antennas, for same lane and opposite lane traffic of a single antenna, or for other suitable combinations antennas signals.

[0054] Antenna signal processor **302** is coupled to rear antenna **306** and front antenna **308**, each of which can be configured similar to the radar antenna shown in U.S. Pat. No. 5,691,724 or other suitable radar antennas, and can be connected to antenna signal processor **302** in a manner similar to that shown in the U.S. Pat. No. 5,691,724 or in other suitable manners. As used herein, the term "couple," and its cognate terms such as "couples" and "coupled", can include a physical connection (such as through a copper conductor), a virtual connection (such as one or more randomly assigned memory locations of a data memory device), a logical connection (such as through one or more logical devices of a semiconducting circuit), a wireless connection, other suitable connections, or a suitable combination of such connections. In one exemplary embodiment, systems and components are coupled to other systems and components through intervening systems and components, such as through an operating system of a digital signal processor.

[0055] Antenna signal processor **302** further includes FFT system **310**, patrol speed system **312**, vehicle tracking system **314**, and relative speed system **316**, each of which can be implemented in hardware, software or a suitable combination of hardware and software, and which can be one or more software systems operating on a digital signal processor. Antenna signal processor **302** receives radar data from one or more radar antennas and generates speed data for vehicles travelling in two or more directions relative to the radar observation point.

[0056] FFT system **310** receives the radar signals generated by front antenna **308** and rear antenna **306**, and performs a fast Fourier transform on the signals. In one exemplary embodiment, fast Fourier analysis can be performed after the signals have been mixed with a reference oscillator signal to create a base band signal and converted to a digital data format. In this manner, front antenna **308** and rear antenna **306** are used to receive reflected radar signals from moving vehicles, after the radar signals have been Doppler shifted. FFT system **310** converts the time domain base band signal into the frequency domain, where the speed of each vehicle can be represented as a frequency band centered at a main frequency and where the frequency shift from the origin represents the speed relative to the radar source. In this manner, the speed of each vehicle can be estimated by the degree of frequency shift from the origin of a frequency domain regime.

[0057] FFT system **310** processes radar signals in suitable time steps, such as one frame every 46 milliseconds. The processing time for a frame of radar data will be a function of the frequency resolution required, where differences in frequency correspond to differences in the speed of vehicles being tracked. Thus, any suitable radar frame refresh rate can be used, up to approximately 100 milliseconds per frame. If the radar frame refresh rate exceeds approximately 100 milliseconds, the time interval between radar frames can result in a decrease in output data quality that is noticeable to the user. The radar frames from each antenna can be processed in a suitable order, such as one front antenna frame followed by one rear antenna frame, two front antenna frames followed by two rear antenna frames, or in other suitable manners.

[0058] FFT system **310** can also process data for one or more of the 8 classes of vehicles previously described. In one exemplary embodiment, FFT system **310** processes data for each of the 8 classes of vehicle, regardless of whether the data for each class is presently being displayed. In this embodiment, it is preferable to support signal processing for up to 8 vehicles simultaneously. In another exemplary embodiment, FFT system **310** can receive control data indicative of the classes of vehicle for which data is being generated, and can restrict the processing of radar data to only those classes, so as to conserve the amount of energy consumed by antenna signal processor **302**.

[0059] Patrol speed system **312** receives the FFT data (such as one or more of the group including the frequency shift, the absolute or relative speed, the signal strength magnitude or relative magnitude ranking, or other suitable data) from FFT system **310** and determines the speed of the patrol vehicle based upon the speed indicated by the background radar reflection. Patrol speed system **312** can use the speed data from the front antenna **308** and rear antenna **306** so as to independently confirm the speed determined from FFT data, can use a speedometer input signal to independently confirm the speed, or can use other suitable processes. Patrol speed system **312** can generate data representative of the patrol vehicle's current ground speed, and can transfer the data to display generator system **304**.

[0060] Vehicle tracking system **314** preferably receives frequency domain data from FFT system **310** and tracks the location of individual vehicles in the frequency domain data. In one exemplary embodiment, vehicle tracking system **314** can assign a suitable identification tag to each vehicle identified from the frequency domain data obtained from FFT system **310** when such vehicles are first identified, and can then track the speed of each vehicle over time, the signal strength associated with each vehicle, and other suitable data. In this manner, vehicle tracking system **314** maintains continuity between successive radar reading scans so as to allow the historical data for vehicles to be tracked and stored. In another exemplary embodiment, vehicle tracking system **314** can determine which vehicle is presently a fastest and which vehicle presently has a strongest signal, such as where historical data is not required.

[0061] Relative speed system **316** determines the actual speed of each vehicle detected by vehicle tracking system **314** from the relative speed generated by vehicle tracking system **314**. In one exemplary embodiment, relative speed system **316** can receive the vehicle speed of each vehicle from vehicle tracking system **314** and the patrol speed from patrol speed system **312**, and can perform suitable operations on the data to generate the actual ground speed of the vehicle. Relative speed system **316** then generates data for use by display generator system **304**, such as data that identifies each vehicle as being either in the same lane, the opposite lane, in front of the reference point, behind the reference point, or in other suitable locations.

[0062] Display generator system **304** includes opposite lane system **318**, same lane system **320**, patrol speed system **324**, and control interface system **322**, each of which can be implemented in hardware, software, or a suitable combination of hardware and software, and which can one or more software systems operating on a general purpose display processor. Display generator system **304** receives display control data, processor control data, vehicle speed data and other suitable data, and generates user-readable display data.

[0063] Opposite lane system **318** generates display data for vehicles traveling in the opposite lane relative to the direction of travel of the reference point. In one exemplary embodiment, opposite lane system **318** receives vehicle speed data derived from radar data generated by front antenna **308** and rear antenna **306** data, and generates display data showing the speed of the vehicle having a fastest speed, a strongest signal, and other suitable data for vehicles in the opposite lane. In another exemplary embodiment, opposite lane system **318** receives one or more pointers that identify a memory location at which the opposite lane vehicle speeds are stored, or other suitable data. Thus, opposite lane system **318** can receive processed data that has initially been generated by front antenna **308** and rear antenna **306**, and can format the data into a predetermined data format for display to an operator.

[0064] Same lane system **320** generates display data for vehicles traveling in the same lane relative to the direction of travel of the reference point. In one exemplary embodiment, same lane system **320** receives vehicle speed data derived from radar data generated by front antenna **308** and rear antenna **306** data, and generates display data showing the speed of the vehicle having a fastest speed, a strongest signal, and other suitable data for vehicles in the same lane. In another exemplary embodiment, same lane system **320** receives one or more pointers that identify a memory location at which the same lane vehicle speeds are stored, or other suitable data. Thus, opposite lane system **318** can receive processed data that has been generated by front antenna **308** and rear antenna **306**, and can format the data into a predetermined data format for display to an operator.

[0065] Patrol speed system **324** receives the patrol speed data from patrol speed system **312**, and generates a patrol speed display for reading by the operator of system **300**. Likewise, patrol speed system **312** can generate display data directly, where suitable, such that the functions of patrol speed system **324** are performed by patrol speed system **312**. In another exemplary embodiment, patrol speed system **324** receives one or more pointers that identify a memory location at which the patrol vehicle speed is stored, or other suitable data.

[0066] Control interface system **322** receives control data from a suitable control input device, such as by using a touch-sensitive display that generates coordinate data from a display, a keyboard, a remote control having wireline or wireless data transfer functionality, voice commands, or other suitable control interfaces. In one exemplary embodiment, control interface system **322** allows a user to configure a display to show vehicle speed data of interest to the user, such as for vehicles in the same lane, in the opposite lane, in front of a reference point, to the rear of a reference point, with a strongest signal in a given direction, with a fastest speed in a given direction, and other suitable vehicles. Control interface system **322** also allows an operator to view historical speed indicators for a vehicle, to freeze a speed for a user-selected vehicle, or to otherwise select a suitable combination of such vehicle speeds or speed data.

[0067] In operation, system **300** allows radar data from two or more radar antennas to be processed and transformed into data for viewing by an operator of a radar speed detection system. System **300** converts the radar data into vehicle speed data, and generates display data containing the vehicle speed data so as to allow an operator to easily confirm vehicle speed observations. System **300** also allows the operator to configure the display to display speed data for vehicles that are in areas of greatest interest to the operator.

[0068] **FIG. 4** is a diagram of a signal strength indicator display **400** showing frequency domain components of the radar signal received from two or more antennas, in accordance with an exemplary embodiment of the present invention. The frequency domain components shown in display **400** include signals derived from at least one antenna oriented directly in front of a vehicle relative to the direction of travel, and at least one antenna oriented directly behind the vehicle.

[0069] The frequency domain signals shown in diagram **400** can be generated by first mixing the radar signal with an oscillator signal so as to generate a base band signal. The base band signal can then be transformed using fast Fourier transform analysis so as to isolate the frequency components of the signal. If more than one antenna is in use, a separate FFT analysis can be performed on the data from each antenna signal. Likewise, additional processes can be performed on the signal to reduce harmonic levels, noise, or other undesired signals. Other suitable techniques can also or alternatively be used.

[0070] As shown in diagram **400**, a plurality of signals are present along the frequency axis, where each signal has a corresponding signal strength. The signals identified on the frequency axis as "PS" are reflections from the background environment and are thus indicative of the speed of the patrol vehicle, which will have a peak positive and negative displacement from the origin of approximately the same value. This peak positive and negative displacement indicates that the patrol vehicle is traveling in a first speed relative to the front facing antenna, and a second speed relative to the rear facing antenna, where the magnitude of the speed is the same but has an opposite sign. Thus, if the speed indicated by the +PS or −PS readings differs, an error signal can be generated to allow diagnostic tests to be performed to determine whether either or both of the signals generated by front antenna **308** and rear antenna **306** are in error. Likewise, if the absolute value of the +PS and −PS

readings are similar within a predetermined tolerance, then the +PS and −PS readings can be used to determine the patrol speed in the absence of a speedometer, such as by averaging or other suitable procedures. Furthermore, the +PS and −PS readings can be used in combination to improve patrol speed tracking and mitigate or eliminate problems that require resetting patrol speed search and acquisition, which can occur when a single PS reading is used to determine patrol speed.

[0071] In addition to vehicle background speed indicators, there will be speed indicators in the fast Fourier transform components for vehicular traffic in the same lane and opposite lane, and from the front and back antennas. For example, the opposite lane front antenna will generate indicators for vehicles at the high positive frequency axis when the patrol vehicle is moving, as shown by "OL-F" signals A and B. In this exemplary embodiment, the indicator for a fastest vehicle, A, is different from the indicator for the vehicle with a strongest signal, B. Likewise, for traffic behind the reference point ("OL-B" signals A and B), the indicator for a fastest vehicle is also the indicator for the vehicle having a strongest signal, namely, "B".

[0072] For vehicular traffic in the same lane in which the patrol vehicle is moving, the relative speeds will be slower, and typically less than the speed of the patrol vehicle, "PS." Thus, for SL-B, the same lane vehicular traffic behind the patrol vehicle, the relative speed of the same lane traffic of interest to the operator will generally be equal to or greater than the speed of the patrol vehicle. In this exemplary embodiment, a fastest signal B is also a strongest signal. Likewise, for the same lane signal from the front, a fastest signal A is not a strongest signal B. Nevertheless, in the event the patrol vehicle is going slower or faster than traffic in the same lane, then it is possible that the relative locations of SL-B and SL-F could be reversed. Thus, for traffic in the same lane when the patrol vehicle is moving, it would be necessary to determine relative location based on the orientation of the antenna that generates the signal. An indicator of the antenna from which the signal was generated can be used to facilitate the simultaneous analysis of front and rear antenna radar data for both same lane and opposite lane vehicular traffic.

[0073] When the patrol vehicle is not moving, the speed of vehicles in the opposite lane will tend to be the same as the speeds for vehicles in the same lane, in which case it will be necessary to distinguish same lane traffic from opposite lane traffic based on the orientation of the antenna and relative speed. For example, for an antenna facing forward from a stationary reference point, vehicular traffic in the opposite lane will generate indicators on the positive frequency axis, and vehicular traffic in the same lane will generate indicators having approximately the same speeds on the negative frequency axis. The antenna facing the rear will generate negative axis indicators for opposite lane traffic, and positive axis indicators for same lane traffic.

[0074] In operation, diagram **400** shows the relative peak frequency component indicators for vehicular traffic in the same and opposite lanes for signals generated from radar antennas in the front and back of a moving patrol vehicle. These indicators can be used to track the speed of vehicles, such as by assigning a suitable tracking identification number to each indicator as it becomes distinguishable, and displaying the vehicle's speed if the indicator for the vehicle shows that it either has a fastest speed or a strongest signal. Signals from the front and back antennas of a patrol vehicle can also be provided with identifiers so as to allow the relative position of each vehicle to be determined.

[0075] **FIG. 5** includes diagrams **500**A and **500**B, which show relative vehicular speeds for understanding concepts of the present invention. Diagram **500**A shows a patrol vehicle "P" moving in the direction shown by the arrow corresponding to P. The vehicle in front of P in the same lane is traveling at a speed of an additional 5 miles per hour relative to P. If P is travelling at 55 miles per hour, then it can be determined that the vehicle in front of P is travelling at 60 miles per hour. Likewise, the vehicle behind P in the same lane is traveling at a relative speed of 5 miles per hour away from P, which corresponds to a speed of 50 miles per hour if P is travelling at 55 miles per hour. In this exemplary embodiment, it would not be possible to determine whether a vehicle is behind or in front of the reference point, nor whether a vehicle is speeding or travelling at a lawful speed, unless the antenna from which the signal originated was known.

[0076] In the opposite lane, the vehicle approaching P is moving at 115 miles an hour relative to P. If P is travelling at 55 miles per hour, it can be determined that the approaching vehicle is traveling 60 miles an hour. The vehicle behind P in the opposite lane is receding from P at 115 miles an hour, such that it can be determined that the vehicle is moving at 60 miles an hour if P is moving at 55. In this exemplary embodiment, it is possible to determine whether a vehicle is behind or in front of the reference point, or whether a vehicle is speeding or travelling at a lawful speed, without knowing which antenna the signal originated from.

[0077] Diagram **500**B shows a stationary patrol vehicle "P." The vehicles in front of P are moving at speeds of 60 miles per hour, but in opposite relative directions. Likewise, the vehicles behind P are also moving at 60 miles per hour, in opposite relative directions. Thus, both the orientation of the antennas and the FFT data of the two radar signals are preferably used to distinguish between forward and rear traffic, and same lane and opposite lane traffic.

[0078] **FIG. 6** is a diagram of a system **600** for generating display data in accordance with an exemplary embodiment of the present invention. System **600** includes either or both of opposite lane system **318** and same lane system **320**, each of which can further include front system **602**, back system **604**, history systems **606** and **612**, fastest systems **608** and **614**, and strongest systems **610** and **616**, each of which can be implemented in hardware, software, or a suitable combination of hardware and software, in which can be one or more software systems operating on a general purpose processing platform. In one exemplary embodiment, system **600** can be implemented as one or more software systems operating on a Motorola MC68336GCFT20 microprocessor that generates user-selectable control fields on an Optrex F-51136 LCD with corresponding user-readable displays and processes command data received therefrom.

[0079] Front system **602** and back system **604** can each be implemented for either or both of opposite lane system **318** and same lane system **320**. In one exemplary embodiment, front system **602** for opposite lane system **318** and same lane system **320** receives processed radar data from a front facing

antenna such as front antenna **308**, while back system **604** for opposite lane system **318** and same lane system **320** receives processed radar data from a rear facing radar antenna such as rear antenna **306**.

[**0080**] History systems **606** and **612** generate historical data displays for vehicles. In one exemplary embodiment, each vehicle that is tracked by a radar speed detection system such as system **300** in **FIG. 3** can be assigned suitable vehicle tracking data that is used to track the vehicle throughout the range of motion detectable by the radar antenna of the radar speed detection system. History systems **606** and **612** can each track the historical data for each vehicle, such as by storing a predetermined number of prior speed readings in a table or other suitable data structure, so as to show whether the vehicle is increasing in speed, decreasing in speed, maintaining constant speed, or otherwise to track speed data. History systems **606** and **612** can also respond to user-entered controls to display or suppress the history data, such as by generating a histogram of speeds for each selected vehicle, by printing out or storing a report to a data memory, or by using other suitable processes.

[**0081**] Fastest systems **608** and **614** are used to generate display data for a fastest vehicle presently being detected in the same lane and the opposite lane by a front facing antenna such as front antenna **308** and a rear facing antenna such as rear antenna **306**, respectively. As shown in diagram **400**, a fastest vehicle can be determined through a fast Fourier transform showing the speed relative to an observation point or other suitable data. In this exemplary embodiment, fastest system **608** receives the FFT data for a fastest vehicle detected by the front antenna for the same and the opposite lanes, and fastest system **614** receives the FFT data for a fastest vehicle detected by the rear antenna for the same and the opposite lanes. In another exemplary embodiment, fastest system **608** can receive the FFT data for all vehicles detected by the front antenna, determine which is a fastest one in each of the same and the opposite lane, and can generate suitable display data. Likewise, fastest system **614** can receive the FFT data for all vehicles detected by the rear antenna, determine a fastest one in the same and the opposite lane, and generate display data. In another exemplary embodiment, fastest systems **608** and **614** receive one or more pointers that identify a memory location at which the fastest vehicle speeds are stored, or other suitable data. Fastest systems **608** and **614** can also respond to user-entered controls to display or suppress the fastest vehicle data, such as by generating a speed display only for selected vehicles, by printing out or storing a report to a data memory, or by using other suitable processes. Other suitable techniques can also or alternatively be used.

[**0082**] Strongest systems **610** and **616** are used to generate data for a display showing the speed of the vehicle having a strongest signal in the same and the opposite lane for a front facing antenna and a rear facing antenna, respectively, such as the speed of a vehicle having the greatest magnitude of signal strength as shown in diagram **400**. As shown in diagram **400**, the speed of the vehicle having a strongest signal can be determined through a fast Fourier transform showing the speed relative to an observation point or other suitable data. In this exemplary embodiment, strongest system **610** receives the FFT data for the vehicles having strongest signals detected by the front antenna for the same and the opposite lanes, and strongest system **616** receives the FFT data for the vehicles having strongest signals detected by the rear antenna for the same and the opposite lanes. In another exemplary embodiment, strongest system **610** can receive the FFT data for all vehicles detected by the front antenna, determine which is a strongest one in each of the same and the opposite lane, and can generate suitable display data. Likewise, strongest system **616** can receive the FFT data for all vehicles detected by the rear antenna, determine a strongest one in the same and the opposite lane, and generate display data. Strongest systems **610** and **616** can also respond to user-entered controls to display or suppress a strongest signal data, such as by generating a display of speeds for each selected vehicle, by printing out or storing a report to a data memory, or by using other suitable processes. Other suitable processes can also or alternatively be used.

[**0083**] In operation, system **600** generates display data for displaying opposite lane and same lane traffic, both in front and behind a point of reference. System **600** can receive control data to suppress the generation of data, can receive control data to move the location of the display to a user selected or predetermined location, and can otherwise generate a user-controllable display for displaying historical data of vehicles, a fastest vehicle, the vehicle generating a strongest signal, and other suitable data.

[**0084**] **FIG. 7** is a diagram of a remote control **700** for providing control data to a radar speed detector system in accordance with an exemplary embodiment of the present invention. Remote control **700** allows an operator to selectively control a display so as to display a suitable combination of front and back radar data, same lane and opposite lane radar data, fastest and strongest signal data, historical data and other suitable data.

[**0085**] System **700** includes controller **702**, which can be a wired or wireless remote control platform that transmits data having preassigned control function associations. In one exemplary embodiment, controller **702** can transmit infrared data that is digitally encoded, where each digital control corresponds to a button or combination of buttons on controller **702**.

[**0086**] Controller **702** further includes user selectable controls such as opposite lane front select **704**, opposite lane back select **706**, same lane front select **708**, same lane back select **710**, strongest select **712**, fastest select **714**, history select **716**, select control **718**, set control **720**, preset **1722**, preset **2724**, and preset **3726**. Opposite lane front select **704** allows the operator to indicate that data for vehicles traveling in the opposite lane in front of the patrol vehicle should be displayed. In one exemplary embodiment, the user can select opposite lane front select **704** and select control **718**, so that all data for vehicles traveling in the opposite lane in front of the patrol vehicle will be displayed, such as the speed of the vehicle with a strongest signal, the speed of a fastest vehicle, historical data for those vehicles, and other suitable data. Likewise, the user can select a suitable combination of controls to limit the amount of data displayed, such as by selecting opposite lane front select **704** and strongest select **712** prior to entering select control **718**. In this manner, the user can indicate that only the speed of the vehicle having a strongest signal in the opposite lane should be displayed, and that no historical data should be displayed for that vehicle.

[0087] Other suitable combinations of controls can also be selected, such that the user can select to view one or more vehicle speed for one or more vehicles in same lane, the opposite lane, in front of the observation point, to the rear of the observation point, and for up to as many as eight vehicles. Likewise, where the display for the radar speed detector does not have a variable format, such as an LCD or other suitable display, selections through controller **702** can have the effect of only allowing LEDs to illuminate in predetermined locations so as to decrease the amount of information being provided through the fixed LED locations and the display.

[0088] In another exemplary embodiment, the display can include a predetermined number of preset LED locations and selections through controller **702** can be used to indicate the data that should provided for each LED location. Additional LED indicators or other data can be used to confirm the operator's selections and assist in the identification of the information being displayed. For example, in an LED display having three LED speed display sectors, each sector can include a first sub-indicator for showing whether it is displaying an opposite lane speed or same lane speed, a second sub-indicator for showing whether it is displaying a front or back speed, and a third sub-indicator for showing whether it is displaying a strongest signal or fastest speed. Thus, in this exemplary embodiment, the LED speed display could indicate a number on top and three LED display sub-indicators underneath that could be used by an operator to determine whether the number correlates to a front or back lane, opposite or same lane, and a fastest speed or strongest signal. Other suitable configurations can likewise be used.

[0089] Controller **702** further includes preset **1722**, preset **2724**, preset **3726**, or other suitable combinations of presets. Presets **722** through **726** can be used to allow an operator to configure a display such that the operator can quickly change between preconfigured displays. In this exemplary embodiment, the operator may have a first preset for viewing relevant speeds of vehicles when the operator is stationary, a second preset for viewing speeds when the operator is moving in traffic in which the traffic is moving slower in same lane than the opposite lane, and a third preset for situations when the operator is moving in traffic in which the same lane traffic is moving fast and the opposite lane traffic is moving slow. In this exemplary embodiment, the operator can quickly reset the radar controls to focus the operator's attention on areas in which the operator is most likely to observe speeding vehicles.

[0090] In operation, controller **700** allows a user to set a display for a radar speed detection system in which the display can simultaneously show radar data for vehicles in front or in back of a radar observation point, in the same lane or opposite lane of the radar observation point, historical data, and other suitable data, in a user selectable combination. Controller **700** thus allows the user to control the display from a location outside of the vehicle or from a position in which access to the radar display unit or keypad for the radar display unit is not readily available.

[0091] **FIG. 8** is a flowchart of a method **800** for processing radar data from two or more antennas in accordance with an exemplary embodiment of the present invention. Method **800** begins at **802** where radar data is received from a front radar antenna or a rear radar antenna, such as where the data is generated in response to timing data or other suitable control data. Likewise, the radar data can be received simultaneously, such as by using separate buffers or processors and radar antennas that continuously generate radar data, or other suitable configurations. Additional radar antennas can be used where suitable, such as to provide two or more radar signals for speed verification, lateral movement measurement, or other suitable purposes. The method then proceeds to step **804**.

[0092] At **804**, the radar data is stored in a buffer. The buffer data can be stored after analog to digital conversion, can be stored in a buffer memory of a digital signal processor, or other suitable buffer memory can be used. Likewise, if processing occurs in parallel, two or more buffers or other suitable processes can be used. The method then proceeds to **806**.

[0093] At **806**, fast Fourier transform analysis is performed on the radar data to isolate the frequency components, such as by performing a separate fast Fourier transform analysis for each radar signal. The fast Fourier transform performed on each base band radar data will isolate frequency components above and below the origin, where each frequency component indicates the speed of an object, has a strength component, and includes other suitable data. The method then proceeds to **808**.

[0094] At **808**, the fastest targets in the opposite lanes are identified and/or tracked. In one exemplary embodiment, a target may first be identified when the radar signal from the target exceeds a minimum threshold in signal magnitude or meets other or additional criteria, where suitable. The target can then be given a suitable tracking number, such that subsequent radar measurements can be correlated to the previously measured location and speed of that target. Likewise, if the radar data indicates that the target has previously been identified, then the latest update of the radar data is associated with that target. In another exemplary embodiment, if historical data is not being maintained, then fastest targets can be processed independently in each data frame. Additional signal processing can also be performed, to provide better target resolution, reduce noise, or for other suitable purposes. The method then proceeds to **810**.

[0095] At **810**, the fastest targets in the same lanes are identified and/or tracked. In one exemplary embodiment, a target may first be identified when the radar signal from the target exceeds a minimum threshold in signal magnitude or meets other or additional criteria, where suitable. The target can then be given a suitable tracking number, such that subsequent radar measurements can be correlated to the previously measured location and speed of that target. Likewise, if the radar data indicates that the target has previously been identified, then the latest update of the radar data is associated with that target. In another exemplary embodiment, if historical data is not being maintained, then fastest targets can be processed independently in each data frame. Additional signal processing can also be performed, to provide better target resolution, reduce noise, or for other suitable purposes. The method then proceeds to **812**.

[0096] At **812**, the targets having strongest signals are identified or tracked for the opposite lane. In one exemplary embodiment, signal strength can be compared after targets have been identified and tracked and the speed has been

determined, so as to identify the targets having greatest signal strengths. In another exemplary embodiment, if historical data is not being maintained, then the targets having strongest signals can be processed independently in each data frame. Additional signal processing can also be performed, to provide better target resolution, reduce noise, or for other suitable purposes. The method then proceeds to **814**.

[**0097**] At **814**, the targets having strongest signals are identified or tracked for the same lane. In one exemplary embodiment, signal strength can be compared after targets have been identified and tracked and the speed has been determined, so as to identify the targets having greatest signal strengths. In another exemplary embodiment, if historical data is not being maintained, then the targets having strongest signals can be processed independently in each data frame. Additional signal processing can also be performed, to provide better target resolution, reduce noise, or for other suitable purposes. The method then proceeds to **816**.

[**0098**] At **816**, the patrol vehicle speed is determined. In one exemplary embodiment, the patrol vehicle speed can be determined by comparing the ground reflection or background radar signal from the front radar antenna, the rear radar antenna, and other suitable radar antennas, so as to obtain independent radar derived patrol vehicle speed. In this regard, using the radar signal from the front antenna to generate front speed data and the radar signal from the rear antenna to generate rear speed data can reduce or eliminate problems that require resetting of patrol speed search and acquisition processes, which can occur when a moving patrol car comes to a stop or in other situations. These problems can occur when the strongest signal present (which typically is representative of the background signal) from a single radar signal includes signals generated from close-by moving vehicles. Using two vehicle speed signals for the patrol vehicle allows such misleading signals to be filtered, such as by comparing the front and rear patrol vehicle speed signal and using the signals when they are within a predetermined tolerance or in accordance with other suitable procedures. Speedometer data can also be received, or other suitable means for tracking patrol vehicle speed can be used. The method then proceeds to **818**.

[**0099**] At **818**, target speed and signal strength data is generated, such as by determining the absolute speed of each target from the relative speed of the target to the patrol vehicle or observation point. Likewise, target signal strength data identifying the target having a strongest signal can be generated. The method then proceeds to **820**.

[**0100**] At **820**, the target signal strength and speed data is transmitted to a display for generation of a user display showing same lane and opposite lane radar data for front and rear antennas. The display can include a display processor, the data can be preformatted for use by a display device, or other suitable configurations can be used. The target signal strength and speed data can include historical speed data, such as to display the change in speed over time for one or more selected targets or for other suitable purposes.

[**0101**] In operation, method **800** allows radar data from two or more antennas to be processed to identify targets having a strongest signal, a fastest target, historical data, or other suitable data. Method **800** allows front and rear antenna, multiple antennas or other suitable combinations of radar antennas to be used so as to provide data to an operator for confirming the identification of speeding vehicles or for other suitable uses.

[**0102**] **FIG. 9** is a flowchart of a method **900** for allowing a user to configure a radar data display in accordance with an exemplary embodiment of the present invention. Method **900** allows the user to select combinations of data, such as rear and front lane data, same and opposite lane data, a fastest target and the target with a strongest signal, and other suitable combinations of data, to assist the user in monitoring the speed of vehicle traffic and for other suitable purposes. Method **900** further allows the user to make such selections by use of a remote control, by selecting features on a touch sensitive screen where contact coordinates are converted into control command data, or through other suitable systems or processes.

[**0103**] Method **900** begins at **902** where controller setting data is received. The controller setting data can be received as a series of controls, method **900** can be performed after each control entry or series of control entries is completed, the controller setting data can be received as one or more presets, or other suitable configurations can be used to obtain the controller setting data. The method then proceeds to **904**.

[**0104**] At **904**, it is determined whether control data has been received for displaying vehicle speed data for vehicles having a strongest signal in the opposite lane in front of the radar observation point. If it is determined that this data should not be displayed, the method proceeds to **908**. Otherwise the method proceeds **906** where the opposite lane front strongest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the opposite lane front strongest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process opposite lane front strongest signal data, or other suitable configurations can be used. The method then proceeds to **908**.

[**0105**] At **908**, it is determined whether control data has been received to display the speed of the vehicle having a fastest speed in front of the radar observation point in the opposite lane. If control data for the opposite lane front fastest signal has not been received, the method proceeds to **912**. Otherwise, the method proceeds to **910** where the opposite lane front fastest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the opposite lane front fastest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process opposite lane front fastest signal data, or other suitable configurations can be used. The method then proceeds to **912**.

[**0106**] At **912**, it is determined whether control data has been received for displaying the speed of the vehicle having a strongest signal in the opposite lane and in back of the radar observation point. If it is determined that the opposite lane back strongest signal should not be displayed, the method proceeds to **916**. Otherwise the method proceeds **914** where the opposite lane back strongest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the opposite lane back stron-

gest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process opposite lane back strongest signal data, or other suitable configurations can be used. The method then proceeds to **916**.

[**0107**] At **916**, it is determined whether control data has been received to display the speed of a fastest vehicle in the opposite lane and in back of the radar observation point. If control data for the opposite lane back fastest signal has not been received, the method proceeds to **920**. Otherwise, the method proceeds to **918** where the opposite lane back fastest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the opposite lane back fastest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process opposite lane back fastest signal data, or other suitable configurations can be used. The method then proceeds to **920**.

[**0108**] At **920**, it is determined whether control data has been received for displaying the speed of the vehicle having a strongest signal in the same lane and in front of the radar observation point. If it is determined that the same lane front strongest signal should not be displayed, the method proceeds to **924**. Otherwise the method proceeds to **922** where the same lane front strongest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the same lane front strongest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process same lane front strongest signal data, or other suitable configurations can be used. The method then proceeds to **924**.

[**0109**] At **924**, it is determined whether control data has been received to display the speed of a fastest vehicle in the same lane and in front of the radar observation point. If control data for the same lane front fastest signal has not been received, the method proceeds to **928**. Otherwise, the method proceeds to **926** where the same lane front fastest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the same lane front fastest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process same lane front fastest signal data, or other suitable configurations can be used. The method then proceeds to **928**.

[**0110**] At **928**, it is determined whether control data has been received for displaying the speed of the vehicle having a strongest signal for the same lane and in back of the radar observation point. If it is determined that the same lane back strongest signal should not be displayed, the method proceeds to **932**. Otherwise the method proceeds to **930** where the same lane back strongest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the same lane back strongest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process same lane back strongest signal data, or other suitable configurations can be used. The method then proceeds to **932**.

[**0111**] At **932**, it is determined whether control data has been received to display the speed of the vehicle having a fastest speed in the same lane and in back of the radar observation point. If control data for the same lane back fastest signal has not been received, the method proceeds to **936**. Otherwise, the method proceeds to **932** where the same lane back fastest data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the same lane back fastest signal, a preset display configuration can be activated, control data can be transmitted to an antenna signal processor to process same lane back fastest signal data, or other suitable configurations can be used. The method then proceeds to **936**.

[**0112**] At **936**, it is determined whether a stored preset display configuration has been selected. If a stored preset display configuration has not been selected, the method proceeds to **940**. Otherwise, the method proceeds to **938** where the preset data is selected for display. In one exemplary embodiment, a buffer read pointer can be used or other suitable settings can be used so as to provide display data for the preset configuration data, control data can be transmitted to an antenna signal processor to process signal data for the preset display configuration, or other suitable configurations can be used. The method then proceeds to **940**.

[**0113**] At **940**, the display template is populated with display data. In one exemplary embodiment, the display data can be stored in one or more predetermined buffers that are continuously updated regardless of whether or not the display configuration for that data has been set. In another exemplary embodiment, control data can be transmitted to a digital signal processor or other suitable systems that reconfigures the digital signal processor to process only the data of interest, such that processing power is not consumed generating display data that has not been selected by the user. Other suitable configurations can also or alternatively be provided. The method then proceeds to **942** where a display is generated meeting the criteria selected by the user. The method then proceeds to **944**.

[**0114**] At **944**, it is determined whether new control setting data has been received. If new control setting data has been received, the method proceeds to **948** and returns to **802**. Otherwise, the method proceeds to **944** where new radar update data is received and the method returns to **940**.

[**0115**] In operation, method **900** allows the user to select one or more controls so as to configure or display data speed data of interest to the user. Method **900** allows the user to select controls by touch sensitive screen controls, button controls, or other suitable controls, and to modify the display in response to changing traffic or patrol conditions.

[**0116**] **FIG. 10** is a flowchart of a method **1000** for selecting the historical display of data in accordance with an exemplary embodiment of the present invention. Method **1000** allows the user to select the display of historical data for a vehicle that has been identified as having a fastest speed or a strongest signal, in same lane or opposite lane as the radar observation point, and using a front or back antenna, in accordance with an exemplary embodiment of the present invention.

[**0117**] Method **1000** begins at **1002** where controller setting data is received. In one exemplary embodiment, the controller setting data can be received by entering commands to a remote controller, by making selections from a touch-sensitive screen, or other suitable controller data. The method proceeds to **1004**.

[0118] At **1004** it is determined whether a user has requested to display historical data for a setting. In one exemplary embodiment, the user can select for display historical data of the speed of a strongest signal, a fastest signal, for vehicles in the front or the rear, for vehicles in the same lane or opposite lane, or other suitable vehicles. If it is determined at **1004** that display of historical data has not been requested, the method proceeds to **1008**. Otherwise the method proceeds to **1006** where historical data is selected for display. In one exemplary embodiment, a predetermined section of buffer memory can be allocated for storing historical data for use in the display (such as the last 100 radar readings), control data can be transmitted to an antenna signal processor to process the selected signal data, or other suitable historical data procedures can be implemented. The method then proceeds to **1008**.

[0119] At **1008**, the display template is populated with data. In one exemplary embodiment, if the template does not include historical display data, then it is populated with the selected speed data. Otherwise, the display template can be populated with historical data for one of the pre-selected speed settings. The method then proceeds to **1010** where the display is generated, such as by lighting predetermined LED structural components, generating an LCD image, or other suitable processes. The method then proceeds to **1012**.

[0120] At **1012**, it is determined whether new control settings have been received. If new control settings have been received, the method returns to **1002**. Otherwise, the method proceeds to **1014** where radar update data is received. The method then returns to **1008**.

[0121] In operation, method **1000** allows historical data for a target to be displayed on a screen, in a user selectable format. Method **1000** thus allows the user to select whether to show or hide historical data for targets, such as targets detected in the front or back of the patrol vehicle, in the same lane or opposite lane, having a strongest signal or a fastest speed, or other suitable users selectable combinations or preset combinations of target characteristics.

[0122] **FIG. 11** is a diagram of a system **1100** for determining patrol car speed in accordance with an exemplary embodiment of the present invention. System **1100** includes candidate selection system **1102**, directivity system **1104**, patrol speed acquisition system **1106**, patrol speed maintenance system **1108**, and pull down effects system **1110**, each of which can be implemented in hardware, software, or a suitable combination of hardware and software, and which can be one or more software systems operating on a Motorola 56307 DSP and associated digital signal processing equipment or other suitable platforms.

[0123] Candidate selection system **1102** can capture the peak values of a suitable number of candidate peaks in the closing spectrum of the front antenna, the corresponding value in the opening spectra, and their FFT bin value. For the rear antenna, candidate selection system **1102** can capture the peak values in the opening spectrum of the rear antenna, the corresponding values in the closing spectrum, and the related FFT bin numbers. The peak values can be taken with the strongest signal first on the list, followed by each peak signal in order of strength, or in other suitable manners.

[0124] Directivity system **1104** receives the values of the candidate peaks in the closing spectrum of the front antenna, the corresponding values in the opening spectra, and the bin numbers, as well as the peak values in the opening spectrum of the rear antenna, the corresponding values in the closing spectrum, and the FFT bin numbers. Directivity system **1104** uses the corresponding signal in the opposite spectrum to establish directivity of the peak signal. In one exemplary embodiment, directivity system **1104** can determine whether the FFT bin numbers match between front bin values and rear bin values to qualify if the speed of the FFT line is below a predetermined value, such as 34 mph, or within +/−1 bin if the speed is above a predetermined value, such as 34 mph. The peak signal value can also be tested several bins higher, either uniformly or as a function of speed, such as to locate a 6 dB and 9 dB signal reduction point or to otherwise confirm that a true local peak value has been detected. The stronger of the front or rear peak signal value can also be tested to determine if it is greater than a predetermined search acquisition value, and the weaker peak signal of front or rear can be checked to determine whether it is consistent with the detection of a peak, such as where the level of the weaker peak signal is within 6 dB below the measured acquisition value. Directivity system **1104** can further determine whether both front and rear peak signals have directional ratios within a predetermined ratio, such as at least 6 dB.

[0125] Patrol speed acquisition system **1106** can track patrol speed using front radar data, rear radar data, or a suitable combination of the front and rear radar data speed. Patrol speed maintenance acquisition system **1106** can monitor determine a front and rear patrol speed, and can generate a patrol speed based on the front patrol speed, the rear patrol speed, the front and rear patrol speed, or other suitable data.

[0126] Patrol speed maintenance system **1108** can track patrol speed with the front patrol speed, the rear patrol speed, or a suitable combination of the front and rear patrol speed. Patrol speed maintenance system **1108** can monitor the front and rear patrol speed, and can take no action unless the front and rear FFT lines are in disagreement, in which case the front and rear patrol speed arrays are taken as before, and the monitoring mode finds the closest front and rear speed bins to the displayed speed bin. If patrol speed maintenance system **1108** determines that one of the two indexes found is not within a predetermined allowable variation, such as 1 bin, of the displayed patrol speed bin, re-acquisition may be performed, such as if it is determined that the variation is not due to pull-down effects or in other suitable manners.

[0127] Pull down effects system **1110** can detect when an index has a momentary variation due to pull down effects from interference, such as may be caused when the patrol car passes through an overpass. In one exemplary embodiment, a predetermined cosine angle can be applied based on a corresponding speed range, such as 18 degrees (95%) for speeds under 20 mph and 25 degrees (90.6%) for speeds over 20 mph. Directional ratio tests on the array peak signal strength can also be varied, such as by requiring 3-dB directivity in tracking over 20 mph, and 6 dB for both front and rear if below 20 mph. If pull-down effects system **1110** or patrol speed maintenance system **1108** determine that the monitoring test has failed for a predetermined period of time, such as 2 seconds, and the last valid patrol speed was at or below a predetermined level such as 20 mph, a new search can be started. Likewise, if the last valid patrol speed

is greater than the predetermined level, the waiting period can be extended, such as to 3 seconds, before a new search is started.

[0128] **FIG. 12** is a diagram of a method **1200** for determining patrol car speed in accordance with an exemplary embodiment of the present invention. Method **1200** begins at **1202** where the peak values of a predetermined number of candidates, such as six candidates, are found in the closing spectrum of the front antenna. The method then proceeds to **1204**, where the corresponding values in the opening spectra, and their FFT bin values are found.

[0129] At **1206**, peak values in the opening spectrum of the rear antenna are captured, and the method proceeds to **1208** where the corresponding values in the closing spectrum of the rear antenna and the related FFT bin numbers are found.

[0130] At **1210**, the peak values are taken with the strongest signal first on the list, followed by each peak signal in order of strength. The method then proceeds to **1212** where the values of the corresponding signal in the opposite spectrum are used to establish directivity of the peak signal, and to **1214** where the front and rear FFT bins are compared to qualify patrol speed. In one exemplary embodiment, the FFT bin numbers can be used to match between front bin value and rear bin value to qualify if the speed of FFT line is below a predetermined value, such as 34 mph, or within +/−a bin tolerance, such as 1 bin, if the speed is above the predetermined value. The peak signal value can also be tested several bins higher, such as depending on speed. For example, the 6 dB and 9 dB signal reduction points can be located to prove a true local peak value. The stronger of the front or rear signal value can also be tested to determine whether it is greater than a predetermined search acquisition value. In addition, the weaker peak signal of front or rear can also be checked for a level that is a predetermined amount below acquisition value, such as 6 dB. A directional ratio of a predetermined value, such as 6 dB, can be applied to both front and rear peak signals.

[0131] At **1216**, the front and rear patrol speed is monitored to determine whether the front and rear FFT lines are in disagreement. The monitoring mode finds the closest front and rear speed bins to the displayed speed bin, and it is determined whether one of the two indexes found is within a predetermined tolerance of the displayed patrol speed bin, such as +/−1 bin.

[0132] If loss of tolerance is not detected, the method returns to **1202**. Otherwise, the method proceeds to **1220** where it is determined if a momentary variation due to pull-down has occurred, such as when passing through an overpass. If the displayed speed bin is under a predetermined level, such as 20 mph, a predetermined cosine angle can be applied, such as 18 degrees (95%), whereas if the displayed speed bin is over the predetermined level, a different cosine angle can be used, such as 25 degrees (90.6%). Directional ratio tests on the array peak signal strength can also be adjusted, such as by using a first level such as 3 dB for determining directivity in tracking at speeds above a predetermined level, such as 20 mph, and a second level such as 6 dB for determining directivity for both front and rear at speeds below the predetermined level. The method then proceeds to **1222**.

[0133] If it is determined at **1222** that the monitoring test has failed for a predetermined period, such as 2 seconds, and the last valid patrol speed was at or below a predetermined level, such as 20 mph, the method can proceed to **1226** where the patrol speed is re-acquired. If it is determined that the last valid patrol speed was greater than the predetermined level, then the waiting period can be extended, such as to 3 seconds. Otherwise, the method returns to **1202** for continued monitoring.

[0134] Although exemplary embodiments of a system and method of the present invention been described in detail herein, those skilled in the art will also recognize that various substitutions and modifications can be made to the systems and methods without departing from the scope and spirit of the appended claims.

What is claimed is:

1. A system for processing vehicle speed data for a vehicle comprising:

a front antenna assembly of the vehicle generating a front digital signal;

a rear antenna assembly of the vehicle generating a rear digital signal;

a fast Fourier transform system converting the front digital signal into front frequency shift data and the rear digital signal into rear frequency shift data; and

a patrol speed system matching the front frequency shift data and the rear frequency shift data and generating a vehicle speed for the vehicle.

2. The system of claim 1 further comprising a candidate selection system selecting one or more candidates in the front frequency shift data and one or more corresponding candidates in the rear frequency shift data.

3. The system of claim 1 further comprising:

a candidate selection system selecting one or more closing spectrum candidates in the front frequency shift data and matching the closing spectrum candidates to corresponding opening spectrum candidates in the front frequency shift data; and

a directivity system receiving the closing spectrum candidates and the opening spectrum candidates and generating directivity data.

4. The system of claim 2 further comprising a directivity system receiving the front frequency shift candidate data and the rear frequency shift candidate data and generating directivity data.

5. The system of claim 1 further comprising a patrol speed maintenance system receiving the front frequency shift data, the rear frequency shift data, and the vehicle speed and determining whether to re-acquire the vehicle speed.

6. The system of claim 1 further comprising a pull down effects system receiving the front frequency shift data, the rear frequency shift data, and the vehicle speed and determining whether the front frequency shift data or the rear frequency shift data has been pulled down due to interference.

7. The system of claim 5 further comprising a pull down effects system receiving the front frequency shift data, the rear frequency shift data, and the vehicle speed and generating pull down effects data, wherein the patrol speed maintenance system receives the pull down effects data and determines whether to re-acquire the vehicle speed based on the pull down effects data.

8. A method for processing vehicle speed data for a vehicle comprising:

generating a first signal at a front antenna of the vehicle;

converting the first signal to a first digital signal;

selecting one or more first frequency component candidates from the first digital signal;

generating a second signal at a rear antenna;

converting the second signal to a second digital signal;

selecting one or more second frequency component candidates from the second digital signal; and

using the first frequency component candidates and the second frequency component candidates to generate an estimated vehicle speed.

9. The method of claim 8 wherein selecting the first frequency component candidates from the first digital signal comprises selecting the first frequency component candidates from a closing spectrum.

10. The method of claim 9 wherein selecting the first frequency component candidates from the first digital signal further comprises matching the first frequency component candidates from the closing spectrum to corresponding first frequency component candidates from an opening spectrum.

11. The method of claim 9 further comprising comparing the closing spectrum first frequency components to the opening spectrum first frequency components to establish directivity.

12. The method of claim 8 wherein selecting the second frequency component candidates from the second digital signal comprises selecting the second frequency component candidates from an opening spectrum.

13. The method of claim 12 wherein selecting the second frequency component candidates from the second digital signal further comprises matching the second frequency component candidates from the opening spectrum to corresponding second frequency component candidates from a closing spectrum.

14. The method of claim 8 further comprising using the first frequency component candidates and the second frequency component candidates to establish directivity.

15. The method of claim 8 further comprising monitoring the first frequency component candidates and the second frequency component candidates to determine whether monitoring failure has occurred.

16. the method of claim 15 further comprising using the first frequency component candidates and the second frequency component candidates to determine whether a momentary variation due to pull down has occurred if it is determined that monitoring failure has occurred.

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