Claims

1. A system for contactless detection and provision of an occupancy status of parking lots in at least one vehicle park comprising:

a frontend sensor unit installed in a carpark, the frontend sensor unit including a plurality of radar modules and a detection board,

wherein each of the radar modules comprises a transmitter configured to transmit L consecutive frequency modulated chirps and at least 3 receivers configured to collect the return chirps, the at least 3 receivers being arranged such that the second receiver (RX2) is a reference, the first receiver (RX1) is located laterally to RX2 and the third receiver (RX3) is located longitudinally to RX2; and

wherein the detection board is adapted to control and receive data from each of the radar modules and execute processes to analyse the data received from the radar modules to determine occupancy status of parking lots, the processes comprising instructions to:

initialise the plurality of radar modules;

receive L return chirps from one of the plurality of radar modules;

capture a time domain data of each of the L return chirps;

translate the time domain data of the L return chirps to frequency domain by applying Fast Fourier Transform (FFT) to form one frame of FFT data, each FFT data comprising amplitude, frequency and phase data;

apply a thresholding algorithm to the FFT data to determine valid peaks;

convert FFT data into ranges and phases; and

initialize position of each parking lot to determine boundary parameter of the parking lot, the boundary parameter including maximum and minimum radial distance (r), maximum and minimum bearing (θ), and maximum and minimum vehicle height (z).

2. The system according to claim 1 wherein the transmitter is configured to transmit a frequency modulated (FM) chirp over a 2 GHz bandwidth.

3. The system according to claim 1 wherein the one frame of FFT data comprises N sequential frequency bins of F_{max}/N frequency resolution and each frequency bin represents a range, R, having a resolution of R_{max}/N and the radial range of obstacles in the radar's field of view presents is a beat frequency with a relationship in a following expression:

$$R = \frac{c_o T f_b}{2\Delta f}$$

where R = radial distance between the radar and the target, c_o = speed of light, 3 x 10^8, Δf = frequency bandwidth, T = time needed to modulate the frequency, f_b = beat frequency.

4. The system according to claim 3 wherein the processes to analyse the data received from the radar modules to determine occupancy status of parking lots comprise instructions to:

determine cylindrical coordinates (r, θ, z) of each of each FFT data with the following expressions,

r = R;

$\theta = sin^{-1}\left(\frac{\Delta\phi\lambda}{2\pi d}\right)$ where $\Delta\emptyset$ = phase difference between RX1 and RX2, d = distance between RX1 and RX2 and λ = wavelength of transmit frequency in free space; and

z = r sin $(sin^{-1}\left(\frac{\Delta\phi\lambda}{2\pi d}\right))$ where $\Delta\emptyset$ = phase difference between RX2 and RX3, d = distance between RX2 and RX3 and λ = wavelength of transmit frequency in free space.

5. The system according to claim 4 wherein the processes to analyse the data received from the radar modules to determine occupancy status of parking lots comprise instructions to:

apply a Density-based spatial clustering of applications with noise (DBSCAN) on the cylindrical coordinates to form distinct clusters; and

determine occupancy status of a parking lot if the distinct clusters is within the boundary parameter of the parking lot for a predetermined number of frames.

6. The system according to claim 5 wherein the instruction to determine occupancy status of a parking lot if the distinct clusters is within the boundary parameter of the parking lot for a predetermined number of frames comprises instructions to:

select a cluster from the distinct clusters and compute an average position r_{avgci}, θ_{avgci}, z_{avgci} of the selected cluster, where avgc refers to average over L chirps;

compares the average position of the selected cluster with boundary conditions corresponding to the parking lot of the selected cluster;

in response to the average position of the selected cluster being within the boundary conditions corresponding to the parking lot of the selected cluster, accumulate the cylindrical coordinates of the selected cluster and store in “LotCount” folder where “LotCount” folder contains the number of clusters for the corresponding parking lot; and

in response to the average position of the selected cluster being outside the boundary conditions corresponding to the parking lot of the selected cluster, disregard the cylindrical coordinates of the selected cluster.

7. The system according to claim 6 wherein the instruction to accumulate the cylindrical coordinates of the selected cluster and store in “LotCount” folder where “LotCount” folder contains the number of clusters for the corresponding parking lot further comprises instructions to:

determines if the number of clusters for the corresponding parking lot is more than a predetermined number of clusters;

in response to the number of clusters for the corresponding parking lot being more than a predetermined number of clusters, change a lotOccupancy[i][j] from zero to one and apply an adaptive algorithm to check boundary conditions of the corresponding parking lot, where [i] refers to sector number and [j] refers to parking lot number.

8. The system according to claim 7 wherein the instruction to apply an adaptive algorithm to check boundary conditions of the corresponding parking lot comprises instructions to:

averages the position (r_{avgfn}, θ_{avgfn}, z_{avgfn}) of the selected cluster over a number of frames with previous position ($r_{avgfn-1}$, $\theta_{avgfn-1}$, $z_{avgfn-1}$) to obtain a new average position (r_{avgf}, θ_{avgf}, z_{avgf}), where avgf refers to average over a number of frames; and

in response to new average position (r_{avgf}, θ_{avgf}, z_{avgf}) is out of reference position (r_{ref}, θ_{ref}, z_{ref}), update boundary conditions for the corresponding parking lot with a fixed pre-defined value to shift boundary conditions closer to new average position.

9. The system according to claim 8 wherein the instruction to determine occupancy status of a parking lot if the distinct clusters are within the boundary parameter of the parking lot for a predetermined number of frames further comprises instructions to:

evaluate lot occupancy information for the corresponding parking lot each frame (n) and sector (i);

in response to LotOccupancy(i)(j)=1, increment frameOccupancy(i)(j); and

in response to frameOccupancy(i)(j) being is equal to or more than a predetermined threshold, determined parking lot (j) as occupied.

10. The system according to claim 9 wherein the predetermined threshold is 8.