DESCRIPTION

AUTONOMOUS LANE INTELLIGENT VISUAL ENHANCED SYSTEM FOR ROAD HAZARD MARKING

FIELD

This invention involves autonomous land-based robots, highway safety devices and systems, and more particularly a dynamic and highly visible intelligent lane marking system.

BACKGROUND OF THE INVENTION

1. Conventionally the traffic cones placed on roads to mark dangers are manually deployed and arranged. These traffic cones are static and have to be manually moved especially in the case of a dynamic obstruction on the road. This poses a danger to workman. During conditions of low light or visibility, this danger is increased.

2. In situations, such as putting up street decorations, tree pruning, plant watering, repairing street lamps, road curb cleaning, cable laying and etc., the road hazard is dynamic and constantly changing. In the conventional manual form, the usual way is to set-up, apart from the working truck and a series of traffic cones, a safety or utility truck, with a safety fender, deployed some 100 to 200 m away from the on-going road curb activity or hazard.

3. Conventionally, there are two current issues:

    a. *Static Situation*: Most of the static hazard situations are static and develop slowly. The traffic cone array configuration is expected to be more or less fixed at the time of deployment, but changes when new considerations arrive.

    b. *Moving Situation*: Most of the moving hazard situations are mobile and develop quickly. The manual safety cone array is expected to be moving in tandem with the moving hazard situation at all time. This compliance requires great resources and effort.

4. The invention specifically addresses the two above-mentioned situations.

BRIEF DESCRIPTION OF THE INVENTION

Object of the Invention

5. The object of the invention to provide an Autonomous Lane Intelligent Visual Enhanced (hereinafter referred to as *'ALIVE'*) System, with a plurality of autonomous mobile traffic cone robots that dynamically and intelligently deploys and adjusts to the developing hazard situation and which enhances visibility to oncoming vehicular traffic.

Disclosure of the Invention

6. The invention discloses a plurality of traffic safety cone robots working under the command and control of a base operator, via an APP in a mobile device, such as, but not limited to, a mobile phone. Each of these traffic cone robots includes a low-profile base cassette body, with a detachable ordinary upper rubber cone section, a rechargeable power supply of 12V, a boost and step-down converter to 24V or down to lower D.C. voltages, a WIFI transceiver device (5.1-5.8 GHz or higher) with antenna sub-assembly, a back-up mobile data network card (SIM-enabled) (on one or a few of the cones) with antenna, a driver stepper-motor (5-10 ms^{-1} or higher), GPS receiver, a gyro-scope, a light sensor, a digital road map, local road-mapping detection, a programmable field computer (as a server-and-client), a power distribution unit, IP-to-RS-232 connection. The base operator, via the main control APP, will carry a mobile device, such a mobile phone for control of the *ALIVE*.

7. Before and after deployment of these traffic cone robots, the traffic cone robots would be ordinarily housed within a rack storage (retrieve-or-release in manual or automatic modes), whereas the traffic cone robots would be charged appropriately in anticipation for the next deployment or mission.

8. In a preferred form as shown in the drawings (moving situation), after releasing the traffic cone robots from its rack storage onto the road surface, the base operator on his/her leading utility truck via his/her phone APP issues a gathering command, the traffic cone robots will then "gather" tightly behind the utility truck, awaiting further instruction. This command is managed by the traffic cone robot's current location and course and speed, as defined by the GPS receiver and the current heading as provided by the gyroscope. Each of this information is then transformed into a set of instructions for the differential stepper motor located at each wheel to move itself to the required location. Similarly, when the base operator issues a deploying command; the traffic cone robots will number themselves automatically according to their assigned relative locations and move quickly towards their allocated relative positions behind the leading utility truck, again each following the logical instructions given to the stepper motors. Each traffic cone robot's position is determined by its GPS receiver and if need be, the traffic cone robots will perform obstacle avoidance relative to its position against the digital road contours, the local road mapping and neighbouring traffic cone robots. Once each traffic cone robot is in its respective relative position, the utility truck can now proceed to moving to what the mission or destination may define. Each traffic cone robot will follow according to its predefined relative location and provide early visual and visible warning to oncoming road users of an impending road hazard ahead.

   As part of the visual signalling requirements, strobe lights will blink in sequence to indicate the direction of safe travel for the other road users.

In the event of lost communication from the base operator, each traffic cone robot is capable of independent operation as well as collision avoidance, via its own server-and-client software.

9. In another preferred form not shown in the drawings (static situation), after releasing the traffic cone robots from its rack storage onto the road surface, the base operator can again via his/her phone APP issues a gathering command, the traffic cone robots will "gather" tightly in the staging area, awaiting further instruction. The base operator can then issue a deploying command; the traffic cone robots will number themselves automatically according to their assigned relative locations and move quickly towards their allocated relative positions. The operative steps are not different from its preferred form for moving situation. As this situation is likely to be slow in development, the base operator can take his/her time to command the traffic cone robot array.

10. In the actual deployments, it is very likely that some of these traffic cone robots may encounter issues like being run-over by vehicles, lose the traffic cones, encountering pot-holes or obstacles, mechanical failures and etc., the server-and-client software on-board each of the traffic cone robots shall automatically and agnostically reassign and rearrange themselves according to the best of their ability to maintain and fulfil the imputed mission. In the event if more traffic cone robots were to recover or added back to the traffic cone robot array, again the server-and-client software on-board shall agnostically reassign and rearrange themselves to the imputed mission.

BRIEF DESCRIPTION OF THE DRAWINGS

11. In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings that illustrate the preferred embodiment of the invention, and wherein:

FIGURE 1 is an overview diagram of a single traffic cone robot of the *ALIVE System* (low profile body) of the preferred embodiment of the invention;

FIGURE 2 is an overview diagram of a single traffic cone robot of the *ALIVE System* in a fully deployed form of the preferred embodiment of the invention;

FIGURE 3 is an overview diagram of a sample traffic cone robot array for following the command and safety utility vehicle of the preferred embodiment of the invention;

FIGURE 4 is an overview diagram of a sample traffic cone robot array encountering actual mechanical and/or physical faults for following the command and safety utility vehicle (with disabled traffic cone robots) of the preferred embodiment of the invention;

FIGURE 5 is an overview diagram of a sample cone robot array showing strobe light sequence of the preferred embodiment of the invention;

FIGURE 6 is a schematic block diagram representing a complete scheme of work of the preferred embodiment of the invention;

FIGURE 7 is an overview diagram of a sample automatic gradient detection flow chart of the preferred embodiment of the invention;

FIGURE 8 is an overview diagram of a sample [agnostic] command flow chart of the preferred embodiment of the invention; and

FIGURE 9 is an overview diagram of a sample manual or automated rack storage system with power charging ports unit of the preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

12. An exemplary embodiment of a preferred form of the invention will now be described with reference to Figures 1 to 9.

13. A single **intelligent traffic cone robot 100** is shown in **FIGURE 1** of the exemplary embodiment of a preferred form of the invention. The external casing is made of a hardened non-metallic material to provide as a safety crash cushion for the traffic cone robot and as a good receptor of sky waves. On top of this external body, it has a water-proof weighted portable **rubber cap 101**, securely fastened against toppling, whilst the body might be in motion or under windy conditions. This rubber cap can be deployed both during the day or night (optional), according to its imputed mission. Within the cassette housing *100*, it contains all sub-systems as described hereinafter. The cassette housing is made water-proof from top down. Small ventilation holes are provided at the bottom. The housing is painted according to the standard colours required of traffic safety cone. The housing also features four or more **recess slots 603** for the purpose of allowing easy and precise vertical stacking and/or discharging during deployment, with minimum stowage volume. Two or more **alignment guides 607** are engraved into the sides of the body for providing precision guidance to the cassette body during docking and recovery operation, so that the cassette body's **power charging unit 103** is aligned correctly to the incoming power line re-attachment.

14. The physical horizontal dimensions of the cassette body is sufficient for the base of a typical standardized rubber traffic cone and the vertical dimensions are kept low profile so that almost all vehicles, in the unforeseeable event of stray motion, can safely pass-over or by it unharmed.

15. This housing is seated firmly onto a stable **spring-loaded platform 102**. This platform is expected to withstand a crash rate of 5 ms^{-1} with another object.

16. At the top of the housing, a single ring of **LED assembly 500**, capable of displaying all colours of the visible spectrum, in sequence or otherwise, according to the base operator's APP program, is installed and mounted securely. It is capable of providing day and night safety visual signals. In between these LEDs, 4 or more **strobe lights 501**, visible by day to at least 300m, are also installed for the purpose of providing a bright strobing directional light that will indicate the correct side for oncoming vehicles to pass safely. In the middle of the housing, a single **large LED 502** of white light is installed. This is to provide illumination of the traffic cone robots during, but not limited to, day, night or low visibility operation.

17. Within the cassette housing, a single **WIFI antenna 401** is attached for relaying, receiving and sending primary instructions to its cone robot group. A separate back-up **SIM antenna 402** is also made available in the event the primary WIFI communication breaks down. This SIM antenna is also needed to link from the **mobile device 901** to the selected few traffic cone robots in the traffic cone robot array.

18. Within the housing, it houses the various **sub-systems 1000** as follows:

    a. A rechargeable **power supply device 201** of 12V is installed to supply power to all its sub-system. The standard standby power supply is 48 or more hours of continuous operation.

Associated with it is the **boost and down converter 202** which is capable of transforming up and down the various D.C. voltages and currents needed for each sub-system. These powers are then distributed via a **power distribution unit 203**. This rechargeable power supply can be charged via **power socket 103**.

b. A programmable computer such as a **field-programmable gate array** (FPGA) **301** is installed in this sub-system. This field computer is capable of acting both as a server and a client managing the entire network of cone array as well as operating the cone robot to its required station-keeping instructions, wherein the software is written in Kotlin, C++, Java and Python languages. The field-computer is pre-loaded with a digital **vector road map 302**, together with **local road mapping 304**, capable of providing obstacles early warning and road contour information. The field computer is also connected to an **IP-to-RS232 device 303** that will provide direct analogue commands to its hardware devices, such as the stepper motor for each of the wheels.

c. The command and control and instruction relay are all done primarily through the primary communication device, such as the local **WIFI network modem 402** and its antenna that uses frequencies between 5.1 and 5.8GHz or higher. The expected range is 2 km or higher. The communication from the base operator to the cone robot's **SIM modem 404** is via the public mobile network using the SIM card that uses public frequencies between 1.8 and 5GHz or higher. In the event of a primary communication failure, all communications will be connected via the backed-up SIM public mobile network.

d. To ensure the traffic cone robot's position, course-over-ground, speed-over-ground, instantaneous heading are known all the time, the traffic cone robot has a **GPS receiver 701** installed to tell its position, course-over-ground and speed-over-ground up to an accuracy of the best GPS satellites (well within 2 m) and a **mini-gyroscope 801** installed to tell its immediate heading, gradient of travel and collision. Together, these devices provide accurate station-keeping and collision avoidance with the other traffic cone robots as well as obstacles.

e. In order to have a highly co-ordinated station-keeping ability, each traffic cone robot is equipped with highly precise **stepper motors 601** with four or more **large wheels (602)** format (to be able to over-come road bumps and cavities), with one of the wheels rotatable in all directions, and capable of up to 10 ms^{-1} in speed for good station-keeping.

f. When the traffic cone robot encounters a road gradient, its immediate heading and/or its course-over-ground and/or speed-over-ground would show unusual readings, due to causes other than formation changes. When this happens, the software within the traffic cone robot would read the local road mapping module *304* to determine if there is a possible gradient or potholes. Actions would be taken if that is the case, otherwise, it would attempt to increase or decrease 3 or more times in various powers to the wheels to determine if that is a gradient detected or pothole encountered. If increase or decrease in power helps in the maintenance of the relative position of the traffic cone robot, the new powers to the wheel are adopted. The encounter is reported back to the base operator and recorded into the local road mapping module *304*. The sample decision-making methodology is depicted in greater detail in the flow chart in **FIGURE 7**.

g. For several or all of the traffic cone robots in the traffic cone robot array, wherein along each of the rear of one of the sides of the cassette body will have a **video camera device 881** installed for the purpose of providing incident reporting and recording. Those traffic cone robots with the video camera installed would always station themselves at the end of the traffic cone robot array facing outwardly to provide the best vantage positions for incident reporting and recording.

19. The fully assembled traffic cone robot ready for deployment and mission that could be placed under the command and control of the leading utility truck base operator is shown in **FIGURE 2**.

20. At the command and control level as shown in the schematic block diagram of the exemplary embodiment of a preferred form of the invention in **FIGURE 6**, the base operator will use a command and control and communications system that coordinates between the traffic cone robots and the main utility vehicle, he/she would carry a **mobile device 900**, such as but not limited to, a mobile phone that is capable of installing and running an **APP 901** specifically written for the purpose, wherein the software is written in Kotlin, C++, Java and Python languages. The APP is capable of, but not limited to, the following single or combination touch method commands:

    a. [configure] – Each traffic cone robot can be configured to a particular relative location. The planning can be done individually or using many array level patterns available.

    b. [gather] – All traffic cone robots will gather together back to the relative staging area near to the base operator. A safe distance each traffic cone robot is maintained.

    c. [assign] – All traffic cone robots can be assigned with a unique identity or automatically assigned by the APP. This will allow individual traffic cone robot to be commandeered without the need to affect the other traffic cone robots in operation.

    d. [deploy] – All traffic cone robots can be deployed at a single command and all traffic cones will race to their relative positions and commence station-keeping immediately.

    e. [exchange] – Two or more traffic cone robots can exchange their relative positions within the station-keeping.

    f. [retire] – All or each traffic cone robots can be retired. The retired traffic cone robots will move to the road curb awaiting further instructions.

    g. [agnostic] – When this command is set, the APP software *901*, installed as an APP to the mobile phone of the base operator, based on the current mission requirement and mission size, will scan for the number of traffic cone robots available for deployment. It will then compute, based on mission deployment requirement, to recommend the best mission configuration. If the recommended mission configuration, the base operator would have to manually configure the deployment. Otherwise, if the suggested mission configuration is accepted, the traffic cone robot array will proceed automatically. In the subsequent events whereby some of the traffic cone robots were to go out of service due to issues like being run-over by vehicles, loss of its rubber caps, encountering pot-holes or obstacles, mechanical failures and etc., or added back to the service, the APP will

automatically issue commands to the remaining traffic cone robots and automatically adjust agnostically, more closely or further apart, to a new configuration that provides, within the best of its ability, maximum effectiveness to the ongoing mission. If the loss of traffic cone robots is assessed to be too great and will not satisfy the current mission requirement, the software would recommend various new mission requirements or manual configurations. The sample decision-making methodology is depicted in greater detail in the flow chart in **FIGURE 8**.

h. [design] – Based on the available number of traffic cone robots, at the start of or during the mission, the base operator can give the APP authority to design the best configuration to fulfil the assigned mission. The APP will recommend the best possible designed configuration and also present any limitations. The APP understands that if below a certain minimum number of traffic cone robots, certain configurations are simply impossible in accomplishing the defined mission objective.

21. A sample of a possible preferred form of the invention where the base operator is on-board the utility truck and the trailing traffic cone robots are to provide a long tail safety distance to warn visible oncoming vehicles of the road work ahead at the time is shown in **FIGURE 3**. In situations wherein low light or visibility, the LEDs on each traffic cone robot provide all-round bright lights as well as a co-ordinated strobe flashing light signal to all oncoming vehicles indicating which side and safe direction the other vehicles should travel. The central large white LED possibly provides the best illumination to light-up with or without the conical rubber cap.

22. In actual operation, it is expected for some of the traffic cone robots to go out of service or return back to service. These possible instances, comprising some of the traffic cone robots being removed or added due to various reasons, are shown in **FIGURE 4.** For example:

a. Being run-over by vehicles, marked as **21**, or mechanical failure, marked as **22**, or falling into a pot hole or obstacle. In this occurrence, the affected traffic cone robot is likely to be inoperable. The affected traffic cone robot would have to be removed physically. The gap thus created in the configuration by the affected traffic cone robot will automatically alert the APP to agnostically redesign the remaining traffic cone robots to cover and close off the said gap.

b. Rubber Cap is unclipped from the base body (as detected by the light sensor on the robot), marked as **23**. In this occurrence, the affected traffic cone robot is likely to be still operable. Unless designed otherwise, the affected traffic cone robot would move automatically to the road curb, awaiting further instruction. The gap thus created in the configuration by the affected traffic cone robot will automatically alert the APP to agnostically redesign the remaining traffic cone robots to cover and close off the said gap. Once the rubber cap is restored, the affected traffic cone robot can re-join the traffic cone robot array and take on any relative position based on new assignment by the base operator. It could be back to the same position as before or an entirely new position depending on the base operator.

23. In the exemplary embodiment of a preferred form of the invention, a sample traffic cone robot array showing strobe light sequence is shown in **FIGURE 5**. When the strobe lights are in operation, the furthest traffic cone robot, say robot no. “1”, labelled as “**1**” in the figure,

would flash first. Depending on the desired strobe light update time rate, fast, medium or slow, the next traffic cone robot no. “2”, labelled as “**2**” in the figure after the brief time interval, would flash next, followed by robot no. “3”, labelled as “**3**” in the figure, again after the brief time interval, and so on. One possible sample flashing sequence is depicted in this figure, that the flashing sequence starts with robot no. “1”, followed by robot no. “2”, followed by robot no. “3”, followed by robot no. “**4**”, followed by robot no. “**5**”, followed by robot no. “**6**”, followed by robot no. “**7**”, followed by robot no. “**8**”, followed by robot no. “**9**”, followed by robot no. “**10**” and so on, until finishing at the traffic cone nearest to the utility truck. When all the robots have taken their turn to flash, there would be a slightly longer time pause before the flashing sequence is repeated starting from robot no. 1. This method of strobe light flash updating will give a visible and visual cue to the other road users on the direction and safe side to pass the road hazard.

24. An overview diagram of a deployment mechanism (in the preferred form of the rack storage for the invention) on the main utility vehicle is shown in **FIGURE 9**, which shows a sample manual or automated **rack storage system 109** with **power charging ports unit 110** of the preferred embodiment of the invention. It features automated or manual rack storage for the traffic cone robots in stowage. The power charging ports unit provides power needed by the robots before their next mission. This power charging ports unit is connected to the vehicle’s battery and/or engine alternator for mobile charging or station-charging when near stationary power source. In the manual storage mode, the traffic cone robots can be stacked or stored from vertically downwards, marked as **6001** and released from the top horizontally outwards, marked as **6002**. In the automated storage mode, the traffic cone robots are stored or released vertically from the bottom, marked as **6003**.

25. Once the traffic cone robots are fully stowed, there would be a locking bar pushing and securing the traffic cone robots into their correct aligned stowage positions. Once secured, the power charging ports unit would then engage each of the traffic cone robots securely and provide power charging.

26. The rack storage as described can easily be attached to or detached from the utility vehicle by using a quick release-and-lock mechanism, such as, but not limited, mounting brackets.

INDUSTRIAL APPLICATION

27. It is to be understood that the above embodiment has been provided only by way of exemplification of this invention, and that further modifications and improvements thereto, as would be apparent to persons skilled in the relevant art, are deemed to fall within the broad scope and ambit of the present invention defined in the claims which follow.

CLAIMS

What is claimed is:

1. An Autonomous Lane Intelligent Visual Enhanced (hereinafter referred to as “ALIVE”) system comprising a plurality of traffic cone robots, in the form of a cassette body, a command and control and communications system, in the form of an APP, that coordinates between the traffic cone robots and the main utility vehicle, and a deployment mechanism, in the form of a rack storage, on the main utility vehicle.

2. The traffic cone robot as claimed in Claim 1, wherein the dimensions of the cassette body are that of an ordinary base of a standardized traffic cone and kept low profile so that most vehicles, can safely pass-over or by it unharmed; whereas the cassette housing is also made water-proof from top down; whereas small ventilation holes are provided at the bottom; and whereas, the housing is painted according to the standard colours required of traffic safety cone.

3. The traffic cone robot as claimed in Claim 1, wherein the cassette body is seated firmly onto a stable spring-loaded platform; whereby this platform is expected to withstand a crash rate of 5 ms-1 with another object.

4. The traffic cone robot as claimed in Claim 1, wherein the external casing of the cassette body is made of a hardened non-metallic material, for providing as a safety crash cushion for the traffic cone robot; and providing good reception of sky waves.

5. The traffic cone robot as claimed in Claim 1, wherein the top of the external casing of the cassette body allows most standardised rubber traffic cones to sit on or fastened to it, whilst remains solidly in place even when the traffic cone robot is in motion or when there are strong winds.

6. The traffic cone robot as claimed in Claim 1, wherein a water-proof weighted portable rubber cap is to be securely clipped to its base body; whereby the fixation is expected to remain solidly in place when in motion and/or under strong winds; whereas this rubber cap can be deployed both during the day or night, according to its imputed mission.

7. The traffic cone robot of Claim 1, wherein the top face of the cassette body will have four or more recess slots for precision wheel stowage of the robot above it so as to facilitate the lowest volume of stacking possible; whereas the traffic cone robot can be discharged and recovered easily when deployed.

8. The traffic cone robot of Claim 1, wherein the cassette body has two or more alignment guides engraved into its sides for providing precision guidance to the cassette body during power charging, docking and recovery operation to the rack storage; in particular, when the traffic cone robot is engaging the power charging ports unit at the rack storage.

9. The traffic cone robot as claimed in Claim 1, wherein the cassette body has a power charging unit installed into its side for the purpose of power charging and to be ready for the next mission.

10. The traffic cone robot as claimed in Claim 1, wherein the cassette body has a large white LED light installed in the middle on top of the cassette body for the purpose of providing illumination of the traffic cone robot to be clearly visible by day, night or in low visibility.

11. The traffic cone robot as claimed in Claim 1, wherein the cassette body has a single ring of LED assembly, capable of displaying all colours of the visible spectrum, installed on top of the cassette body for the purpose of providing visible light signals in sequence or otherwise, during, but not limited to, night operation in accordance to the base operator's APP program.

12. The traffic cone robot as claimed in Claim 1, wherein the cassette body has four or more strobe lights, capable of being visible by day to at least 300m, installed within the ring of LED assembly for the purpose of providing clear visible light signals in sequence and directional indication to the other vehicles during the day and/or night operation in accordance to the base operator's APP program.

13. The traffic cone robot as claimed in Claim 1, wherein the cassette body has four or more highly precise stepper motor assemblies, each controlling a large format wheel, installed, capable of moving on road surface, over-coming road bumps and cavities, whereas one of the wheels may be rotatable in all directions, and capable of up to 10 ms-1 and above in speed for the purpose of providing a highly co-ordinated station-keeping ability of the traffic cone robot.

14. The traffic cone robot as claimed in Claim 1, wherein the cassette body has an array of sub-systems installed within its cassette body, for the purposes of command, control and communication with the base operator and its fellow traffic cone robots.

15. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a rechargeable power supply device of 12V battery pack installed for the purpose of supplying power to all its sub-systems, whereas the standard standby power supply is 48 or more hours of continuous operation.

16. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a boost and down converter installed for the purpose of transforming up and down the various D.C. voltages and currents, such as, but not limited to, 3.3V, 5V, 12V and 24V, needed for each sub-system.

17. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a power distribution unit installed for the purpose of delivering the various D.C. voltages and currents, such as, but not limited to, 3.3V, 5V, 12V and 24V, needed for each sub-system.

18. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a WIFI transceiver device that uses frequencies between 5.1 and 5.8GHz or higher installed for the purpose of providing a primary WIFI local area network coverage of up to 2km for reception and transmission.

19. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a mobile broadband SIM transceiver device that uses frequencies between 1.8 and 5.0GHz or higher installed to provide a secondary WIFI wide area network of nation-wide coverage, whereas this network communication is being used as a backup to the primary network communication as well

as the primary network communication between the base operator and the selected traffic cone robots.

20. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a GPS receiver that detects its own position, course-over-ground and speed-over-ground, installed for the purpose of accurate station-keeping and collision avoidance between the other traffic cone robots and obstacles.

21. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a mini-gyroscope that detects its own immediate heading, gradient of travel and collision, installed for the purpose of accurate station-keeping, gradient travelling and collision detection and avoidance between the other traffic cone robots and obstacles; such as, but not limited to, when the traffic cone robot encounters a road gradient, its immediate heading and/or its course-over-ground and/or speed-over-ground would show unusual readings, due to causes other than formation changes; whereas when this happens, the software within the traffic cone robot would read the local road mapping module to determine if there is a possible gradient or potholes; whereas actions would be taken if that is the case, otherwise, it would attempt to increase or decrease three or more times in various powers to the wheels to determine if that is a gradient detected or pothole encountered; whereas if increase or decrease in power helps in the maintenance of the relative position of the traffic cone robot, the new powers to the wheel are adopted; whereas the encounter is reported back to the base operator and recorded into the local road mapping module.

22. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a video camera device installed for the purpose of providing incident reporting and recording; whereby the video camera can be installed optionally on some or all of the traffic cone robots to provide the best vantage positions for incident reporting and recording.

23. The array of sub-systems as claimed in Claim 14, wherein the array of sub-systems has a programmable field computer such as a field-programmable gate array (FPGA) installed, for providing the hardware for the server-and-client software to be installed.

24. The field-programmable gate array (FPGA) as claimed in Claim 23, wherein the programmable field computer has a client-and-server software installed, whereas this software is capable of acting both as a server and a client managing the entire network of cone array as well as operating the traffic cone robot to its required station-keeping instructions; further, the server software serves at any one time to take over any break-down of communication channel from the base operator and continues proper operation until communication channel is restored; whereas the server also serves as an intermediate way-point for communication between the base operator and his/her outer most remote traffic cone robots; whereas the client software deals with the proper running of the traffic cone robot to its required station-keeping and obeys commands from either the base operator or server, whereas the software is written in Kotlin, C++, Java and Python languages.

25. The field-programmable gate array (FPGA) as claimed in Claim 23, wherein the programmable field computer has a vector road map installed, whereas this vector road map is capable of providing all contours of any roads within the vicinity.

26. The field-programmable gate array (FPGA) as claimed in Claim 23, wherein the programmable field computer has a local road mapping method installed, whereas this local road mapping method will store for reuse all local contours of any roads within the vicinity that were previously been traversed.

27. The field-programmable gate array (FPGA) as claimed in Claim 23, wherein the programmable field computer has an IP-to-RS232 device installed for the purpose of providing direct fail-safe analogue commands to its hardware devices, such as the stepper motor for each of the wheels.

28. The command and control and communications system (in the form of an APP) of Claim 1 comprises of a hand-held mobile device, such as, but not limited to, a mobile phone that is capable of installing the APP; an APP that is capable of, but not limited to, following single or combination touch method commands, remotely managing the traffic cone robot array; and a proprietary strobe light sequence method is installed and held in possession of the base operator.

29. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [configure] command is installed as a single touch, whereas each traffic cone robot can then be configured to a particular relative location; whereas the planning can be done individually or using many array level patterns available.

30. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [gather] command is installed as a single touch; whereas all traffic cone robots will gather together back to the relative staging area near to the base operator; whereas a safe distance each traffic cone robot is maintained.

31. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [assign] command is installed as a single touch, whereas all traffic cone robots can be assigned with a unique identity or automatically assigned by the APP, whereas this will allow individual traffic cone robot to be commandeered without the need to affect the other traffic cone robots in operation.

32. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [deploy] command is installed as a single touch, whereas all traffic cone robots can be deployed at a single command and all traffic cones will race to their relative positions and commence station-keeping immediately.

33. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [exchange] command is installed as a single touch, whereas two or more traffic cone robots can exchange their relative positions within the station-keeping.

34. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [retire] command is installed as a single touch, whereas all or each traffic cone robots can be retired, whereas the retired traffic cone robots will move to the road curb awaiting further instructions.

35. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [agnostic] command is installed as a single touch, whereas if any of the traffic cone robots were to go out of service due to issues like being run-over by vehicles, loss of its

rubber caps, encountering pot-holes or obstacles, mechanical failures and etc., the APP will issue commands to the remaining traffic cone robots and automatically adjust agnostically, more closely or further apart or otherwise, to a new configuration that provides, within the best of its ability, maximum effectiveness to the ongoing mission, whereas, if the loss of traffic cone robots is assessed to be too great and will not satisfy the current mission requirement, the software would recommend various new mission requirements or manual configurations.

36. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a [design] command is installed as a single touch, whereas based on the available number of traffic cone robots, at the start of or during the mission, the base operator can give the APP authority to design the best configuration to fulfil the assigned mission; whereas the APP will recommend the best possible designed configuration and also present any limitations; whereas the APP understands that if below a certain minimum number of traffic cone robots, certain configurations are simply impossible in accomplishing the defined mission objective.

37. The command and control and communications system (in the form of an APP) as claimed in Claim 28, wherein a proprietary strobe light sequence method is installed, whereas under command and control of the base operator, the strobe light sequence method can be initiated, whereas the furthest traffic cone robot will then flash its strobe lights first; after a planned brief time interval, the next traffic cone robot next to the furthest cone robot would flash, and again after the same brief time interval, the next traffic cone robot would flash and so on; whereas when all the robots have taken their turn to flash, there would be a slightly longer time pause before the flashing sequence is repeated starting from the same furthest robot; whereas this method of strobe light flash updating will give a visible and visual cue to the other road users on the direction and safe side to pass the road hazard.

38. The deployment mechanism of Claim 1 comprises of a rack storage that is capable of, but not limited to, storing and stowing a plurality of the traffic cone robots; a power charging ports unit; and a specific quick release or lock mechanism that can attach the said rack storage to or detach the same from the utility vehicle.

39. The rack storage as claimed in Claim 38, wherein a sample rack storage system can feature an automated or manual rack storage for the traffic cone robots in stowage; whereas in a sample manual storage mode, the traffic cone robots can be stored from vertically downwards and released from the top horizontally outwards, whereas in a sample automated storage mode, the traffic cone robots are stored or released vertically from the bottom onto the road surface.

40. The power charging ports unit as claimed in Claim 38, wherein the power charging ports unit is installed within the rack storage for the purpose of power charging the traffic cone robots when in stowage; whereas the power charging ports unit can be automatically or manually attached; whereas the power charging ports unit is designed for in-vehicle or base-station charging; whereas once the traffic cone robots are fully stowed, there would be a locking bar pushing and securing the traffic cone robots into their correct aligned stowage positions; whereas once secured, the power charging ports unit would then engage each of the traffic cone robots securely and provide power charging.

41. The specific quick release or lock mechanism as claimed in Claim 38, wherein the specific quick release or lock mechanism that can attach the said rack storage to or detach the same from

the utility vehicle, via mounting brackets, is installed, for the purpose of quick deployment of traffic cone robots and recovery operations.