Awareness Analysis of Smart Car Parking System in Heterogeneous High Density Clusters

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ABSTRACT
The swiftly growing urban population of Nigeria is generating lots of tension in the cities in line with the rapid increase of vehicles. This is due to hitherto reliance on the present parking system which has no standard to check for parking spaces, hence generating problems such as traffic congestion, time wastage in search of parking slot, fuel consumption/CO emission, insecurity of vehicles etc. This work presents a quantitative statistical survey analysis conducted in selected metropolitan cities in Port Harcourt, Nigeria. The aim is to create awareness on Smart Car Parking System (SCPS) for heterogeneous clustered environments. The results of the conducted analysis showed that the awareness of this innovative technology is still at its tender stage in Nigeria. Findings shows that people are willing to adopt this new technology to assist in overcoming the challenges faced in the present parking system that is unstructured. A brief description of proposed SCPS based on Big data hardware is presented.

Keywords  
Disruptive Car Parks, Internet of Things, embedded computing, smart city Awareness, Cloud data mining.

1. INTRODUCTION
Smart Car Parking System is a concept that deals with directing vehicles to a designated parking slot with the aid of some intelligent devices i.e., sensors, LCD, cameras, etc. As a typical component of a smart city application, smart car park (SCP) is a good illustration of how the Internet of Things (IoT) will be pervasively deployed in today’s daily living environments to provide different services to different users [1]. The (IoT) is the network of physical objects, i.e., devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data [2]. These datasets could be used to study parking trends in car parks.

Finding a vacant parking space is a common problem in most metropolitan cities in Nigeria which especially occurs in popular and well-travelled places like shopping complexes, stadiums and other well-travelled areas or tourist attraction spots. This situation has become more serious especially during their peak time, be it holiday seasons, sales carnivals or any other festivals. This problem arises as most of the time; individuals come by their transport means, resulting in abundance or high number of transports competing for a few vacant parking spaces and security for their parked vehicle.

The urban population in Nigeria has increased significantly from 45.2 million in 1960 to 182.2 million in 2015 and is estimated to grow to around 203.13 million by the year 2020. Also, the number and size of cities have also increased at the same pace [3]. All most all large metropolitan cities face the same problem that the public transport system is either obsolete or is insufficient to cater to the commuter demands and needs.

As a result of which, public transportation is associated with unfavorable consequences like discomfort due to overcrowding, time delays due to long routes and unsatisfactory service due to lack of maintenance. These problems and constraints force the people to travel by their own cars [4].

A statistical report from Federal Road Safety Commission revealed that in 2010 about 6.6 million vehicles plied Nigerian roads and in 2015 about 9.8 million vehicles also plied Nigerian road resulting in about 69.4% increase in vehicles between 2010 to 2015. This increase in vehicles has really posed a problem in Nigeria’s parking system because everybody still depend on the traditional/manual means of parking which heavily relies on human interaction with the physical environment [5].

However, considering the problems constantly faced in the Nigerian parking system like improper parking, traffic congestion, time wastage in locating a vacant slot as well as fuel consumption, insecurity of vehicles, Co emission etc., there is the need for an efficient parking system that would be able to address these problems. This is a good feature for a smart city (society) design depicted in Appendix A.

Obviously, the SCPS concentrates on solving the problem of proper parking management by utilizing advance technologies which will definitely help in alleviating the current traffic problems. While much effort has been invested into smart parking lot management with a specific focus on traffic engineering of the sensor readings from the parking spots to the gateway, the optimal placement of optional fingerprint scanner detection and sensor devices in a parking lot will increase high rate of security with regards to car theft. This is an important parameter which an efficient parking management system depends.

The following are some of the benefits to be derived in the SCPS. They include: best use of available space, proper parking management scheme, security of vehicles, reduced time in search of a vacant slot, less fuel consumption/CO emission, less traffic congestion in parking lot etc. SCPS creates an efficient model since the search time is
significantly reduced due to the detailed information provided by the associated sensors in the system. These details could enable drivers avoid fully occupied parks and locate vacant parking spaces with ease. With SCPS, illegal vehicles parked along the road which can create traffic congestion, can be channeled into such parks.

2. LITERATURE REVIEW

Various parking systems have been done in the past. Obviously, the car parking systems implemented in developed countries are done with advanced technologies deployed in the car park. This section reviews various work done on SCPS.

In [6], the existing SPS, has been divided into five major categories namely, Parking Guidance and Information System (PGIS), transit based information system, smart payment system, E-parking and automated parking [7].

A very simplified classification on the existing SPS has been fully carried out in [6]. The authors in [8] tackled the problems facing car parking environments while proposing a SCPS using both qualitative and quantitative methodologies. Results of data gathered through questionnaires, interview and observation proved that the time taken to search for a vacant parking slot and less availability of car parks is actually the primary cause of parking problems in manual/traditional parking. The system incorporated the use of infrared sensors, LED and other hardware/software component to overcome these challenges.

The authors in [9] in other to educate the populace and create awareness about Smart car parking System conducted a survey questionnaire to acquire information on issues people face in manual parking system. Information of the findings of the needs assessment and environmental scan of the parking problems proved that people are willing to adopt the new technology of SCPS and also that space availability is the main issue faced while parking.

Another work done in automated car park was proposed by [10]. In this work, qualitative survey was conducted to find out major challenges facing manual/traditional parking scheme. Analysis of the survey conducted concluded that improper parking/no reserve parking for students at university campus usually generates the tension faced in parking lot on campus. To alleviate the tension in the parking lot, the system leverage on the use of ANPR cameras and a mobile application [11].

In this paper, after realizing the system model, infrared sensors and IoT modules will be introduced to monitor and detect the presence of vehicles in parking lot. This is part of the proposed Big data hardware. In order to tackle issues generated in manual/traditional car park, multi-layered car parking system with an elevator consisting of automating processes, various Big data hardware will be chosen for accuracy and reliability in SCPS. This will eradicate the issues associated with that of single layer car parking system.

2.1 Research Gap

After the review of the works in literature, the following were the established research gaps.

1. Most works only concentrated on the use of questionnaires as the only means of gathering information regarding to present parking issues.
2. Some works only focused on gathering information about the causes of parking issues in manual/traditional parking lot but failed to create awareness on the technology for adoption.
3. Absence of sensor driven vehicle detection in the parking lot, lacking real time parking information
4. By introducing wireless sensors alongside with IoT Modules, big data can be explored in structuring parking patterns. The datasets obtained could become so large that challenges such as data capture, storage, analysis, data curation, search, sharing, transfer, visualization, querying, updating and information privacy becomes a major issue. With Big data, predictive analytics could be applied on the datasets in order to carry out feature extraction of data values for smart computation.

3. METHODOLOGY

This research focused on creating awareness on SCPS based on IoT and also make it a reality in Nigerian context. An empirical survey was carried out to understand IoT based SCPS awareness in high density clusters. How this could be implemented within a sample population was investigated. The first step applied was to find out issues that are peculiar to users (drivers) when trying to park their vehicles in the parking lot. The work investigated the issues drivers face mostly in course of parking which usually result in traffic congestion in the parking lot. In this work also, effort was made to find out whether individual drivers are willing to embrace the new technology of SCPS.

Data collections were made through selected field areas such as Niger Delta Development Center (NDDC), Destiny Made Real Foundation (DMR), Ken Saro-Wiwa Polytechnic and Port Harcourt Polytechnic; all in Rivers State, Nigeria where parking issues has actually posed a major challenge. Individuals from these locations constituted the sample space.

An organized survey questionnaire with multi-stage sampling was used which contained about 13 items questions given the respondents. The sample population varied from male to female whose educational qualification which varied from O’level or its equivalent, B.Sc, M.Sc or its equivalent to Ph.D. Young adults to aged people with varied income groups were included also. With the multi-stage survey, the populace was educated on SCPS and its benefits when adopted in Nigerian context. Results of the statistical findings were synthesized with scientific tools for the design frame work.

3.1 Data Analysis and Collection

Method of data analysis was done using descriptive Statistics and ANOVA to ascertain the perception of participants on the SCPS, and all analysis were carried out using SPSS 20. Data gathering techniques such as questionnaires and observations were used in the data collection process in order to gather quantitative and qualitative data required for designing the required specification for the new IoT driven SCPS.

3.2 Analysis of Research questionnaire

This section presents and analyses data congregated during the data collection phase.

Table 3.1 Are you aware of Smart car Parking System

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>Yes</td>
<td>20</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>59</td>
<td>73.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>79</td>
<td>98.8</td>
</tr>
<tr>
<td>Missing</td>
<td>System</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>80</td>
<td>100.0</td>
</tr>
</tbody>
</table>
From the analysis of the questionnaires, out of a total of 80 (100%) participants, 51 (63.8%) are staff of NDDC, 1 (1.3%) work with Federal Ministry of Internal Affairs, 15 (18.8%) are staff of Ken-Poly, 1 (1.3%) work with Total while 2 (2.5%) are staff of Destiny Made Real Foundation. 10 (12.5%) worked with Port Harcourt Polytechnic.

Form Table 3.1, out of 80 questionnaire distributed to participants, 79 (98.8%) responded while 1 (1.3%) did not respond to either of the options. From the analysis, 20 (25.0%) are aware of Smart car Parking System while 59 (73.8) are not aware of Smart Car Parking system.

Table 3.2 shows the SPSS results on how long it take K to locate a parking slot in minutes.

<table>
<thead>
<tr>
<th>Table 3.2. Duration Statistics for locating a Parking lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Std. Error of Mean</td>
</tr>
<tr>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
</tbody>
</table>

Table 3.3 shows similar results with SPSS on how long does it takes to locate a parking slot in Minutes.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>15.0</td>
<td>35.5</td>
</tr>
<tr>
<td>Valid 4</td>
<td>15</td>
<td>18.8</td>
<td>54.3</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>8.8</td>
<td>73.1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2.5</td>
<td>75.8</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>2.5</td>
<td>78.3</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>7.5</td>
<td>85.8</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>12.5</td>
<td>90.3</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>1.3</td>
<td>91.5</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>2.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Research Question One: Is the mean time to locate parking slots about 5 minutes?

Hypothesis 1:

Hₐ: The mean time to locate parking slots is not about 5mins
H₀: The mean time to locate parking slots is about 5mins.

Table 3.4. One-Sample Test.

<table>
<thead>
<tr>
<th>How long does it take to locate a parking slot in minutes</th>
<th>df</th>
<th>Sig (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Intervals of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>.635</td>
<td>.79</td>
<td>.527</td>
<td>.225</td>
<td>.48</td>
</tr>
</tbody>
</table>

Conclusion: The mean time to locate parking slots is about 5 minutes (P > 0.05)

Research Question two: Are the time spent to locate parking slot related to the cause of traffic congestion in parking slot?

Hypothesis 2:

H₀: There is no difference in mean time to locate parking slot between the causes of traffic congestion in parking slot.
H₁: There is difference in mean time to locate parking slot between the causes of traffic congestion in parking slot.

Table 3.5 How long does it take you to locate a parking lots in minutes

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>27.43</td>
<td>4</td>
<td>6.858</td>
<td>671</td>
</tr>
<tr>
<td>Within Groups</td>
<td>766.519</td>
<td>75</td>
<td>10.220</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>793.950</td>
<td>79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From table 3.5, the null hypothesis (P>0.05) is rejected, hence, it is concluded that there is significant difference in mean time to locate parking slot between the causes of traffic congestion in parking slot.

Research Question 3: Are the time spent to locate parking slot related to the issues faced while parking?

Hypothesis Three

H₀: There is no difference in mean time to locate parking slot and the issues faced while parking
H₁: There is difference in mean time to locate parking slot and the issues faced while parking.

Table 3.6. How long does it take to locate a parking slot/Minutes?

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>38.325</td>
<td>3</td>
<td>12.775</td>
<td>1.285</td>
</tr>
<tr>
<td>Within Groups</td>
<td>755.625</td>
<td>76</td>
<td>9.942</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>793.950</td>
<td>79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From table 3.6, the null hypothesis (P>0.05) is rejected, hence, it is concluded that there is significant difference in mean time to locate parking slot in relation to the issues faced while parking. This work proposes a system that helps users automatically find a free parking space based on intelligent information gathering considering the distance and the total number of free places in each car park. The system should be able to find an available parking space upon a request by the user. Beside, a probable solution set can be offered once the car park is fully occupied.

Again at the parking slot shown in Appendix A, the system can be applied in smart underground basement framework, smart apartment, public parking place, shopping mall, etc. The smart actuating device will comprise of motors, chain links, car loading pallet; steel rope, cylinder and hydraulic pump.

In its operation (refer to Appendix A), the base parking slot will be designed with multi-level columns and multi-rows for
parking the cars via sensor directivity. Each level in the slots will be designed with a vacant bidirectional space. The spaces from the lower levels to the higher can be lifted automatically except the space in the topmost level. Once a car needs to park or exit, all spaces under the car space constitutes a lifting channel under this smart space. In context, the smart space will flexibly move upward and then in a downward fashion with zero degree of freedom. If the smart space, locates the ground, the car can now then exit and or move in smartly. In the design features, the following attributes are included:

- IoT Module with dashboard interfaces.
- Complex operational modes of drive system.
- Hydraulic high speed drive
- Motor steel rope rolling drive
- Motor gear box chain drive
- Safeguard functions on crashing protection
- Galvanized anti-corrosion treatment.
- Automatic Control System with fault diagnosis and display for a smart maintenance and troubleshooting.
- Initial zero loading (motor startup)
- Energy savings and environmental protection (greenness).

Appendix B shows the trajectory illustration for the SCPS.

4. CONCLUSION
From the analysis of the statistic survey conducted, this work observed the SCPS has not gained any significant ground in Nigeria and people barely know about this innovative technology. However, considering the tension generated in the parking lot like improper parking, time wastage in search of a parking lot, insecurity of vehicles etc., people are willing to adopt this new technology. Statistical analysis based the item statements, and selected respondents have been discussed. This work recommends that significant amount of research studies must be encouraged in Nigeria so as to address the related challenges and limitations faced in parking lot. Also, there is need to ensure that SCPS is introduced in Nigeria. This will provide a more robust and reliable parking system. Future work will focus on the system implementation and validation.

5. REFERENCES

6. APPENDIX
Appendix A: An Illustration of a High density smart parking cluster (Source: Smart Garage Proposal, 2017)
Appendix B: Proposed parking reservation system message framework for heterogeneous clusters.

Display Dashboard:
There are 2 Parking lots reserved at NDDC
After 40 minutes, Reservation >> CLOSED

Total Available Smart Space >> 12/300

Total Available Smart Space >> 14/310

YOU ARE LOCATED HERE!!!

Elos

DMR

KSW

UNIPORT

UPTH