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**The 2nd International Conference
on Applied Science
and Technology (iCAST)
24th - 25th OCTOBER 2019**

**Social Science (iCAST-SS)
Engineering Science (iCAST-ES)**



POLITEKNIK NEGERI BALI



**Bali Nusa Dua Convention Center
Bali, Indonesia**

PROCEEDING

**The 2nd International Conference on Applied Science
and Technology (iCAST)**

**APPLIED RESEARCH IN GREEN DEVELOPMENT
THROUGH MILLENNIAL INDUSTRIALIZATION:
CHALLENGES IN BALANCING ECONOMIC
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PREFACE



The 2nd International Conference on Applied Science and Technology (iCAST) 2019, has been held in Bali Nusa Dua Convention Center, Bali, Indonesia from 24-25 October 2019 as a continuation of the previous iCAST conference that had been held in Manado, North Sulawesi. In this year, the conference theme is "Applied Research in Green Development Through Millennial Industrialization: Challenges in Balancing Economics Advancement". This theme is taken by considering that half of the workforce in various industries will be made up of millennials in 2020.

Polytechnics, as higher education institution that provide skilled and professional study, must be able to prepare millennials supporting green development that focused on responsiveness to the environment, efficiency in uses of earth's limited resources, and sensitivity to the community and culture. To answer this challenge, this conference has been held in two groups of science, i.e., social science and engineering science to present the results of applied research to find a balance between economic and environmental sustainability. This prestigious conference is aimed at bringing together researchers and experts in intelligent technology and social science from educational institutions, R & D, industry, government and the community to exchange and share ideas, knowledge through a discussion of a wide range of issues related to green development through millennial industrialization. This conference has been held in two groups of science, i.e., social science (iCAST-SS) and engineering science (iCAST-ES). Research findings and results on latest technology are presented in this conference. A side event on exhibition of technology products as the outcomes of joint research between students and lecturers will also be displayed around the conference areas

Finally, thanks to all those who participated in this 2nd International Conference on Applied Science and Technology (iCAST) 2019 in particular conference participants and all members of the organizing committee for their willing to organize the conference as good as possible.

Warm regards,

Dr. Dra. Ni Nyoman Aryaningsih, MM
General Chair

TABLE OF CONTENTS

01	Student attendance based on face detection and recognition with PCA Algorithm using LattePanda	
	A Rafiq, Pujono, E D Puspita Sari	Pages 1 - 10
02	Webqual 4.0 and ISO/IEC 9126 Method for website quality evaluation of higher education	
	E Budiman, N Puspitasari, M Taruk , E Maria	Pages 11 - 18
03	Analysis of student difficulties in calculus and intervention strategies for problematic students	
	P Silalahi, I R Pratiwi	Pages 19 - 23
04	Influence of some variables in online marketing strategy on interests of student entrepreneurs	
	I M Patulak, R Alex, N Dengen, M Taruk	Pages 24 - 30
05	The effect of ratio of pineapple skin water and coconut water in cellulose membrane production and its application	
	F Faridah, E Elwina, R Fauzan, M Marzuki, C Azmi, A Arifien, Milawarni	Pages 31 – 37
06	Test the e-commerce model in coconut product smes in North Sulawesi	
	M A S Kondo, S Sawidin, D I E Sundah, C Pua	Pages 38 - 41
07	Implementation of communication system between Siemens PLC S7-1200 with Omron PLC CP1L-EL20DT1-D for induction motor speed controller	
	M Yusuf, A Rohman	Pages 42 - 50

08	The measurement of end-user computing satisfaction of the banjar accounting information system	
	I W Suasnawa, P A W Santiary, I M S A Jaya	Pages 51 - 56
09	Smart green house's hydroponic with arduino uno	
	Muharnis, K Syah, J Lianda	Pages 57 – 63
10	Development of ball direction prediction system for wheeled soccer robot goalkeeper using trigonometry technique and neural network method	
	P Priyonggo, A Khumaidi, D B Setiwan, S T Sarena, R Y Adhitya	Pages 64 - 71
11	Academic information system mobile-web based at the cilacap nature school (SACIL)	
	R Purwanto, L Syafirullah, I Bahroni	Pages 72 - 82
12	Usability measurement of media interactive learning for primary school students	
	S Tyas	Pages 83 - 86
13	Automatic calculation of form accreditation as internal assessment simulation in Electrical Department of Manado State Polytechnic	
	S B Walukow, F J Doringin, O E Melo, A Polii, A Wauran	Pages 87 - 91
14	Evaluation of the application PermenKUKM No. 13 in cooperative savings and loan accounting Bali State Polytechnic Cooperative	
	I K Sugiarta, C Ardina , I K Parnata	Pages 92 - 97
15	The development of sokasi woven business management model at Sulahan Village, Susut Sub-district, Bangli Regency	
	N L M Wijayati, I K Muderana, N Supiatni	Pages 98 - 104
16	Analysis of cabbage production in Batunya Village, Baturiti Sub-district, Tabanan Regency	
	N Supiatni, S M Suryaniadi	Pages 105 - 112

17	Decision support system application of education staff performance allowance in Manado State Polytechnic by using Saw Method	Pages 113 - 121
	O Melo, A Kimbal, A Wauran	
18	Experience of the faculty of knowledge in the application of quality management system to obtain ISO certification	Pages 122 - 130
	M F Idan	
19	Choice model of transportation mode for international tourists based on travel characteristic in Bali	Pages 131 - 137
	P Hermawati, I N R Aryana, I G M O Aryawan	
20	Low-cost transformer tester for laboratory module	Pages 138 - 148
	I M Purbawa, I W R Ardana, I K S B Budarsa, I G N A Saputra	
21	Development of spreadsheet-based applications for analysis and design of reinforced concrete beam as a learning tool in the Departmet of Civil Engineering at Bali State Polytechnic.	Pages 149 - 153
	I N Suardika, I W Intara, N K S E Yuni	
22	Mini Simlitabmas software development in P3M Bali State Polytechnic	Pages 154 - 158
	I K Suja	
23	A design of pyrolysis test-bed for plastic waste	Pages 159 - 162
	I P G Sopan Rahtika, P W Sunu, I M Suarta, I W Suastawa, I N D Susila	

Experimental analysis on solar powered mobile robot as the prototype for environmentally friendly automated transportation

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Abstract. An unmanned vehicle can be deployed in a dull area such as a repetitive task of a transport vehicle in a factory setting which can be considered as automated transportation. The current problem faced by the transportation sectors are the reduction of fossil fuel availability, therefore, solar-powered automated transport vehicle is a great alternative. This paper discussed the experimental analysis of solar-powered mobile robot as the prototype for environmentally friendly automated transportation. The solar cell output is used to charge the capacitor banks functioning as the substitute for a battery system. The robot moves from one station to another imitating the stations in a factory scenario. The solar-powered robot is equipped with a voltage sensor to ensure efficient charging time. The charging time was conducted in 5 days to show the charging fluctuation affected by external factors such as weather condition. The highest average charging in a day is 4.96 V during 100.687 Lux of irradiance received by the solar cell. The highest power required during the loaded task is 0.0121 W, and during unloaded is 0.0106 W. The experiment results show that the proposed method is effective for environmentally friendly automated transportation.

1. Introduction

The unmanned vehicle has been an interesting topic investigated by many researchers with different objectives and control design. The unmanned vehicle is mostly deployed in the area of dull, dirty, and dangerous, such as an underwater vehicle, flying drone, and ground vehicle for surveillance. The dull task can be including a transport vehicle in a factory setting where it should move from one point (station) to another within the same time schedules, duration, and area. This repetitive mission can be handled by an unmanned vehicle to liberate a drive from boredom and in the long term can reduce the overall manufacture cost in a factory. This type of unmanned vehicle can be considered as automated transportation that can transport either human passengers or goods [1-3].

The automated transport system is a crucial factor in factory site where savings in this sector will significantly help to save overall production costs. Another problem currently faced by the transportation sectors are the reduction of fossil fuel availability while the demand for fuels is increasing. This condition insists that people search for renewable energy from nature. For countries located in equator, the most suitable type of renewable energies is the energy from the sun [4-6]. The price of solar panels



is decreasing due to its reduction in panel production costs. Therefore, the solar-powered automated transport vehicle is an excellent alternative for the environment since solar power emits zero CO₂ emission.

The investigation of the possibility of solar power automated transportation can be started by using a typical two-differential driven mobile robot as the prototype of an environmentally friendly vehicle. This paper discussed the experimental analysis of solar power mobile robot as the prototype for environmentally friendly automated transportation [7, 8]. The solar panel output is used to charge the capacitor banks functioning as the substitute for a battery system. The application of capacitor bank is to ensure speedy and efficient charging time [9, 10]. The experiment is conducted with a transport setting where the vehicle has to stop in four stations.

2. Solar powered environmentally friendly automated transportation setting

The mobile robot considered in this study is a two-wheel differential driven mobile robot, which is made simple to focus on analysing the experimental analysis of the solar-powered robot. Figure 1 shows the block diagram of solar power automated transport. The main controller of this robot is Arduino Mega 2560 that receives input from two sensors to move the robot by varying the input to DC motors as the actuators in this study. The solar cell applied is 12 Volt 1.5 Watt to charge 500 Farad capacitor banks that are the main power supply of the robot. The voltage sensor is required to monitor the amount of voltage inputted to capacitor banks. The robot is moved on the track to imitate the redundant tracks of the real application of automated transport system. The electrical connection of Figure 1 is shown in Figure 2.

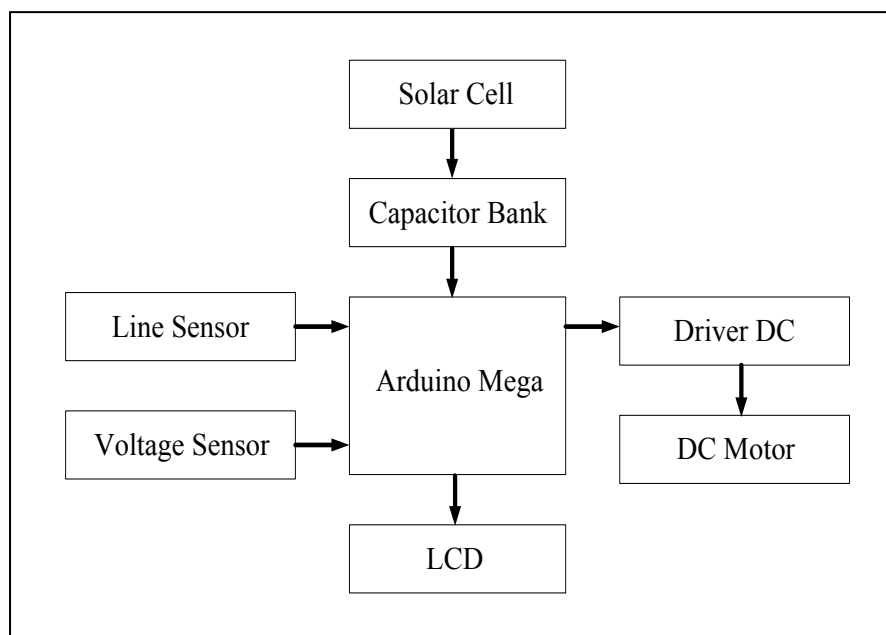


Figure 1. Block diagram of solar powered mobile robot considered in this study.

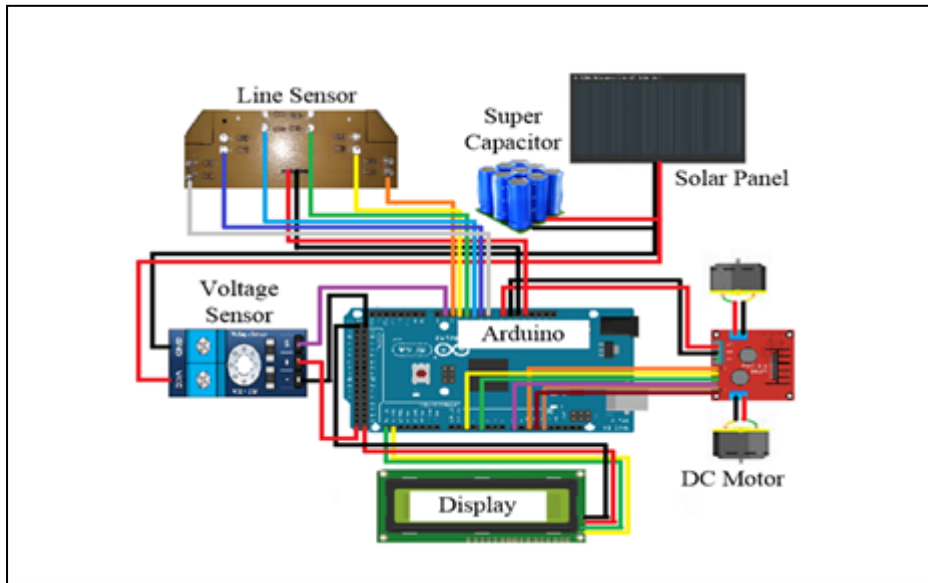


Figure 2. Electrical circuit of components used in this study.

Figure 3 Shows the prototype of a sound transport system considered in this study. The robot is equipped with a box to transport any object; in this study, the object is oranges.

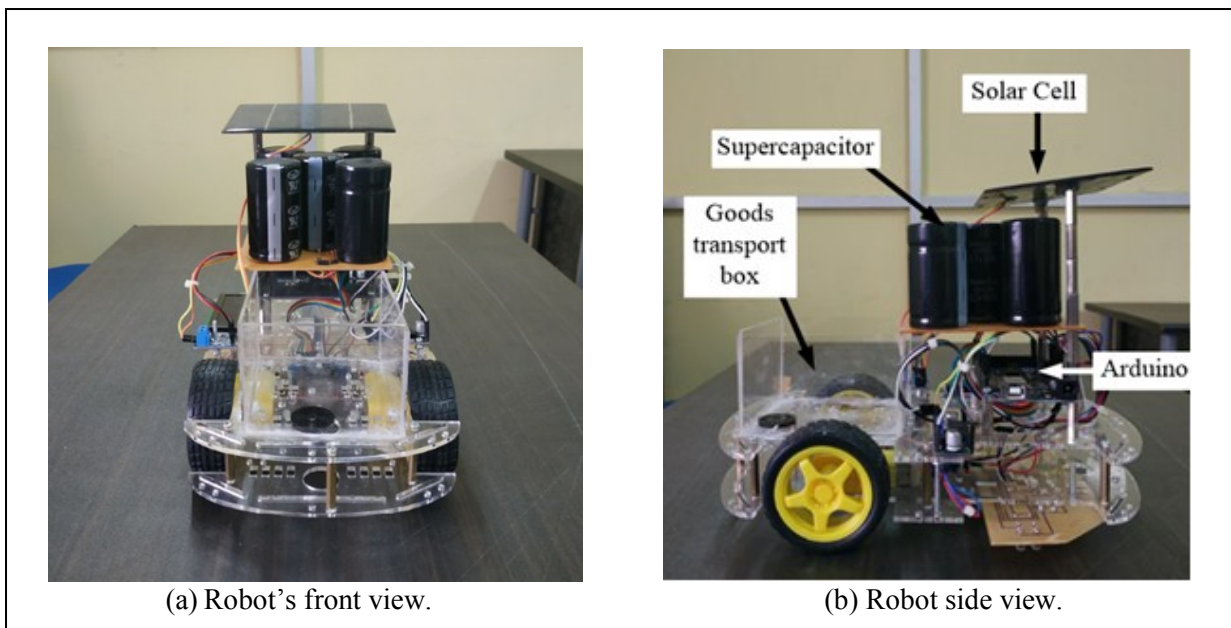


Figure 3. Mobile robot as the prototype of goods transport system.

Solar cell efficiency is calculated by:

$$\eta = \frac{P}{I_{RF} \times A_C} \tag{1}$$

where η is the efficiency, P is power (Watt), I_{RF} is the incident radiation flux (watt/m²), and A_C is the area of collector (m²).

3. Results and discussion

To show the effectiveness of the proposed method, an experiment is conducted to test how the robot is working by using power from the capacitor banks, which are previously charged by a solar cell. The experimental setting of the prototype of an automated transportation system is given in Figure 4. The setting is mimicking the static transport system inside a factory complex where the vehicle is moving from one point (station) to another point continuously at a particular time.

Figure 4a shows the detail of the experiment scenario; the robot moves from station 1 to station 4 and stop in each station to load and unload the goods. The considered goods in this study are two oranges. The robot started to move from Station 1 bringing loads (two oranges) to Station 2. At Station 2, the robot stopped for 5 secs, the oranges were unloaded, and the robot moved to Station 3. At Station 3, the robot stopped, and oranges were loaded. The robot moved to Station 4 bringing two oranges, and back to Station 1 without any loads. The process of loading and unloading was representing the goods transportation system in a factory. The loads and delay time of stopping in one station can be adjusted according to the needs. The experiment is shown in Figure 4a – 4f. The experiment was conducted 20 times where the robot can successfully finish the task shown in Table 1, where “√” indicates that the robot is able to stop and continue its task in every station.

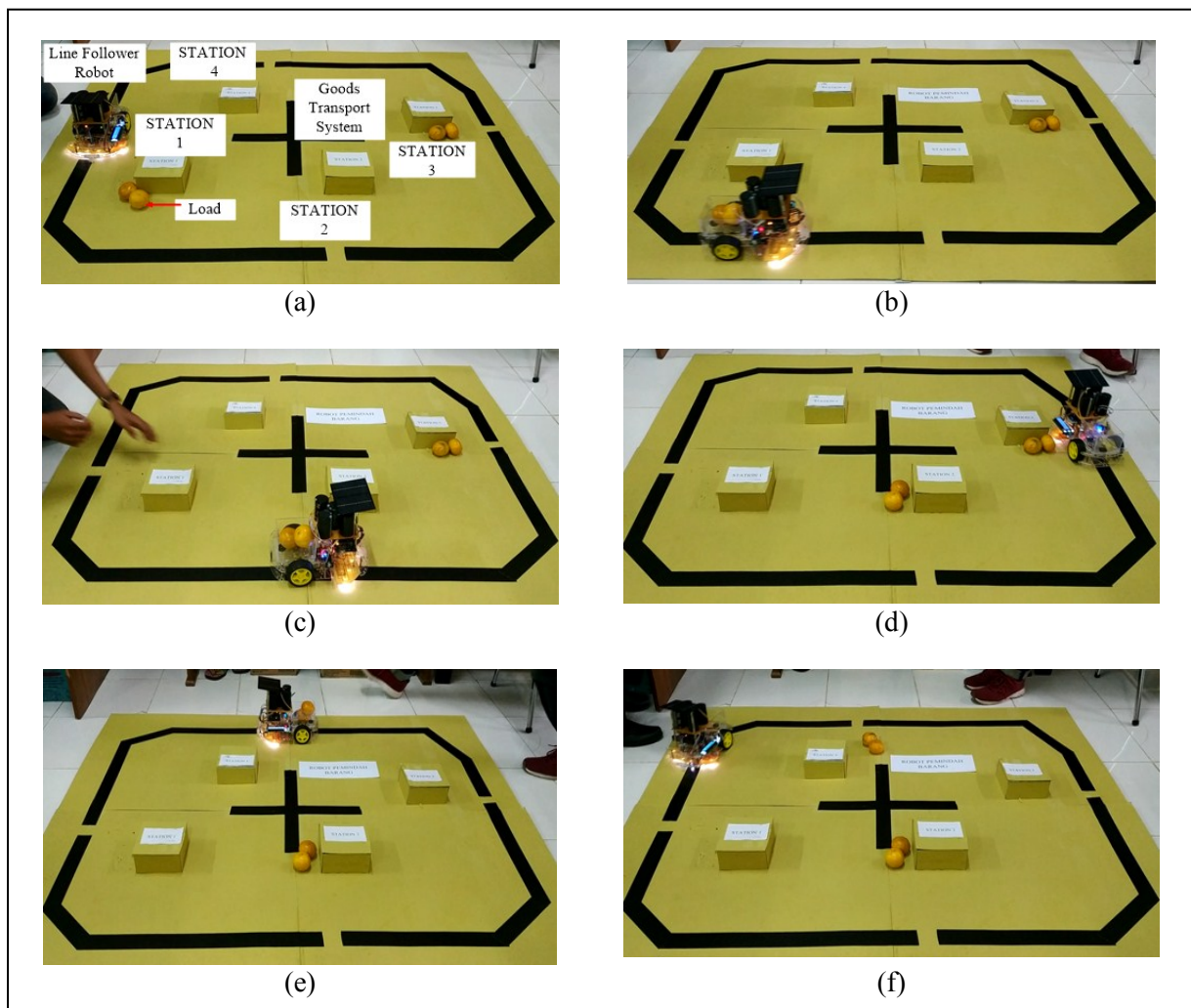


Figure 4. Screenshot of solar powered goods transport system.

Table 1. Hit-rate data to show the robot's effectiveness.

Attempts	Station 1	Station 2	Station 3	Station 4
1	✓	✓	✓	✓
2	✓	✓	✓	✓
3	✓	✓	✓	✓
4	✓	✓	✓	✓
5	✓	✓	✓	✓
6	✓	✓	✓	✓
7	✓	✓	✓	✓
8	✓	✓	✓	✓
9	✓	✓	✓	✓
10	✓	✓	✓	✓
11	✓	✓	✓	✓
12	✓	✓	✓	✓
13	✓	✓	✓	✓
14	✓	✓	✓	✓
15	✓	✓	✓	✓
16	✓	✓	✓	✓
17	✓	✓	✓	✓
18	✓	✓	✓	✓
19	✓	✓	✓	✓
20	✓	✓	✓	✓

Robot performance is strongly influenced by the availability of power at the capacitor bank, with sufficient power supply, the robot can perform well. The availability of power in the capacitor bank is influenced by the amount of energy received by the solar cell to charge the capacitor bank. The energy received by the solar cell is affected by many external factors such as the amount of lux from sunrays received, the weather condition, the ambient temperature, and the humidity of the environment [11]. Table 2 shows the external factors affecting solar cell performance in 5 days during solar cell charging and experiments from July 5th to July 9th.

A solar cell is mounted on a robot as a charger for the robot. In this study, the power results from the conversion of sunlight by solar cells as a source of electrical energy stored in 2.7 V of 500 farads capacitors. Since the robot needs 12 V to drive, the 2.7 V 500-farad capacitors are connected in series to reach the amount of needed voltage source. The series-connected results in 13.5 V. The charging time is fluctuating depending on external factors given in Table 3.

Table 3 shows the power, voltage, and current produced by the installed solar cell to charge the capacitor banks. The charging time was conducted in three terms, 09.00 to 11.00 AM, 11.00 AM to 01.00 PM, 01.00 to 03.00 PM. Solar cell efficiency is proportional to the produced voltage obtained. During the sunny times, the Power, voltage, and current produced are much higher than cloudy and rainy days. This condition is due to the nature of direct electricity generation by a solar cell or also called a photovoltaic effect. The highest generated voltage is on July 5th, 2019 during the first term (09.00 to 11.00 AM); 4.96 V with the irradiance of 100.687 Lux. The lowest generated voltage is on July 8th, 2019 at the third term (01.00 to 03.00 PM); 0.2 V with the irradiance of 6054 Lux. The low generated voltage is due to a rainy day without enough light intensity. The charging is continuously to reach enough power to move the DC motors installed on the robot.

The highest generated voltage is on July 9th, 2019 with 12.64 V, and the lowest generated voltage is on July 8th, 2019 with 5.32 V. The generated voltage is not constant in a day due to the condition of every term, such as on July 8th, 2019, the weather was cloudy, cloudy and rainy. Table 4 shows the comparison of power required to move the robot during loaded and unloaded. Averagely, the power during unloading (P wo Load) was 0.0106 W and the power during loading (P with Load) was 0.0121 W.

Table 2. The external factors during capacitor banks charging.

Date	Time	Lux	Weather	Ambient Temperature (°C)	Humidity (%)
July 5 th , 2019	09.00 to 11.00 AM	96153	Sunny	29	20.76
July 5 th , 2019	11.00 AM to 01.00 PM	100687	Sunny	31	45.19
July 5 th , 2019	01.00 to 03.00 PM	10921	Rainy	31	48.65
July 6 th , 2019	09.00 to 11.00 AM	100420	Sunny	29	27.18
July 6 th , 2019	11.00 AM to 01.00 PM	89950	Sunny	30	26.51
July 6 th , 2019	01.00 to 03.00 PM	14624	Rainy	30	32.29
July 7 th , 2019	09.00 to 11.00 AM	91215	Sunny	29	41.98
July 7 th , 2019	11.00 AM to 01.00 PM	100021	Sunny	32	52.52
July 7 th , 2019	01.00 to 03.00 PM	63875	Cloudy	30	50.12
July 8 th , 2019	09.00 to 11.00 AM	87152	Cloudy	30	31.15
July 8 th , 2019	11.00 AM to 01.00 PM	72148	Cloudy	30	28.76
July 8 th , 2019	01.00 to 03.00 PM	6054	Rainy	29	46.22
July 9 th , 2019	09.00 to 11.00 AM	96894	Sunny	31	30.18
July 9 th , 2019	11.00 AM to 01.00 PM	100152	Sunny	31	32.37
July 9 th , 2019	01.00 to 03.00 PM	100319	Sunny	32	24.06

Table 3. The power, voltage, and current produced to powered mobile robot.

Date	Charging Time	Power (Watt)	Voltage (Volt)	Current (Ampere)	Efficiency (%)
July 5 th , 2019	09.00 to 11.00 AM	0.1239	4.13	0.03	1.267
July 5 th , 2019	11.00 AM to 01.00 PM	0.1488	4.96	0.03	1.522
July 5 th , 2019	01.00 to 03.00 PM	0.0489	1.63	0.03	0.005
July 6 th , 2019	09.00 to 11.00 AM	0.147	4.90	0.03	1.503
July 6 th , 2019	11.00 AM to 01.00 PM	0.0765	2.55	0.03	0.007
July 6 th , 2019	01.00 to 03.00 PM	0.0129	0.43	0.03	0.001
July 7 th , 2019	09.00 to 11.00 AM	0.1065	3.55	0.03	0.01
July 7 th , 2019	11.00 AM to 01.00 PM	0.1242	4.14	0.03	0.012
July 7 th , 2019	01.00 to 03.00 PM	0.0477	1.59	0.03	0.004
July 8 th , 2019	09.00 to 11.00 AM	0.0915	3.05	0.03	0.009
July 8 th , 2019	11.00 AM to 01.00 PM	0.0621	2.07	0.03	0.006
July 8 th , 2019	01.00 to 03.00 PM	0.006	0.2	0.03	0.0006
July 9 th , 2019	09.00 to 11.00 AM	0.1176	3.92	0.03	0.012
July 9 th , 2019	11.00 AM to 01.00 PM	0.1215	4.05	0.03	0.012
July 9 th , 2019	01.00 to 03.00 PM	0.1401	4.67	0.03	0.014

Table 4. Power taken from capacitor bank during with and without load.

Experiment	P _{wo_Load} (Watt)	P _{with_Load} (Watt)
1	0.0108	0.0117
2	0.0096	0.0129
3	0,0108	0.0129
4	0.0114	0.0114
5	0.0099	0.0117
6	0.0111	0.0123
7	0.0108	0.012

The automated transportation system is possible to be realised by using power converted from solar irradiance converted by the solar cell. The performance is good indicated by the experiment results.

4. Conclusions

This paper discusses the experimental analysis of on solar-powered mobile robot as the prototype for environmentally friendly automated transportation. The prototype in this study is a two-wheel differential driven mobile robot equipped with a line sensor to differentiate its black track against a white background. The robot is moved from one station to other three stations to imitate the stations in a factory scenario. The solar-powered robot is also equipped with a voltage sensor to ensure efficient charging time. The charging time was conducted in 5 days to show the charging fluctuation affected by external factors such as weather condition. The highest average charging in a day is 4.96 V during 100.687 lux of irradiance received by the solar cell. The robot moves as expected carrying load and unloaded during its task. The highest power required during the loaded task is 0.0121 W, and during unloaded is 0.0106 W. The experiment results show that the proposed method is effective for environmentally friendly automated transportation.

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