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by

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by

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DEDICATION

To my beloved parents; Ilham and Kamal for teaching me the importance of education, and always motivated me to pursue my dreams. To my dear sister; Shaymaa for teaching me and taking care of me during my childhood. To my lovely wife; Nurul Najmin for supporting me during pursuing my PhD.

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ABSTRACT

Traffic congestion has been recognized as a major problem in the modern urban cities as the number of vehicles is increasing and the urbanization, which led to waste the driver's time and accordingly frustration. In order to solve this problem, an integrated system has been developed for managing a single intersection's traffic lights with high stability at all levels of demand. It has circumvented most of the problems those usually pop up when using image processing, obsolete technologies, or wrong control algorithms. Vehicular Ad-hoc Network (VANET) technology with appropriate control algorithm was used to collect road status data and deliver them to the intersection's traffic light controller to make efficient, accurate, and dynamic decisions about traffic light phase planning. The first decision made by the controlling algorithm was the sequence priority. This algorithm expands the Djikestra's shortest path algorithm to choose the optimal dual-green-phase to be operated at a moment of time. While, the second decision made by controlling algorithm was the phase's time. This algorithm was inspired by the operation of the Dynamic Time Division Multiple Access (D-TDMA) method where a dynamic number of time slots reserved for a data stream based on its traffic demand. A set of five case studies were applied on a customized intersection's traffic light simulation tool to evaluate the anticipated approach's performance then compared to other existing methods. Each experiment had a different level of demand applied on the intersection. The simulation has shown that, the dynamic queue length detection feature has added more accuracy to the decision made by the controller. In addition, the decision making algorithms have shown the ability to dynamically organize the traffic light phase plan according to the level of demand and the other collected factors. The real time operation of the system has imitated and reflected similar decisions made by a policeman on duty, by bearing in mind the queue length on each direction and its route proprieties.

ABSTRAK

Kesesakan trafik telah diiktiraf sebagai masalah utama di kawasan bandar moden apabila bilangan kenderaan dan pembangunan meningkat dan ianya telah membuatkan pembaziran masa pemandu dan menyebabkan tekanan. Dalam usaha untuk menyelesaikan masalah ini, satu sistem bersepadu telah dibangunkan untuk menguruskan lampu isyarat di persimpangan tunggal dengan kestabilan yang tinggi di semua peringkat permintaan. Sistem ini dapat mengatasi kebanyakan masalah yang biasanya hadir apabila menggunakan pemprosesan imej, teknologi lama, atau algoritma kawalan yang salah. Teknologi VANET (Vehicular Ad-hoc Network) dengan algoritma kawalan yang sesuai telah digunakan untuk mengumpul data status jalan raya dan menyampaikannya kepada pengawal lampu trafik persimpangan bagi mendapatkan keputusan yang cekap, tepat, dan dinamik mengenai perancangan fasa lampu isyarat. Keputusan pertama yang dibuat oleh algoritma kawalan adalah keutamaan urutan. Algoritma ini memperluaskan laluan algoritma terpendek di Dijkestra untuk memilih optimum dual-hijau-fasa yang akan dikendalikan di masa tertentu. Manakala, keputusan kedua yang dibuat oleh algoritma kawasalan adalah fasa masa. Algoritma ini telah diilhamkan daripada kaedah pengendalian dinamik-TDMA (Dynamic Time Division Multiple Access) di mana beberapa slot masa dinamik telah dikhaskan untuk aliran data berdasarkan kepada permintaan trafik. Lima kes kajian telah digunakan pada alat simulasi lampu isyarat di persimpangan yang sesuai untuk menilai prestasi bagi pendekatan yang dijangkakan berbanding dengan kaedah lain yang sedia ada. Setiap eksperimen mempunyai perbezaan tahap permintaan yang digunakan pada persimpangan. Simulasi tersebut telah menunjukkan bahawa, pengesanan dinamik beratur telah meningkatkan keputusan yang lebih tepat yang dibuat oleh pengawalan. Di samping itu, pembuat keputusan algoritma telah menunjukkan keupayaan dinamik bagi menguruskan pelan fasa lampu isyarat mengikut tahap permintaan dan faktor-faktor lain yang dikumpulkan operasi sistem masa sebenar. Operasi masa sebenar sistem ini dapat menyampaikan keputusan yang

biasanya dibuat oleh polis trafik yang bertugas dengan mengambil kira panjang barisan dan arah laluan.

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LIST OF ABBREVIATIONS

AVD	Ambulance VANET Device
BM1	First Benchmark Method
BM2	Second Benchmark Method
CFVA	Confirmation of First Vehicle Arrival
CVD	Civilian VANET Device
DSRC	Dedicated Short Range Communication
DT3P	Dynamic Traffic-light Phase Plan Protocol
EA_R	Eastern Approach (to-Right lane)
EA_T	Eastern Approach (Through lane)
FVD	Firefighter VANET Device
GCx	Flag=1 (Lane X Currently Green), Flag =0 (Lane X Currently not Green)
GN	New phase Green light index (number)
GPS	Global Positioning System
GTN	New Green Time
GVD	Governmental car VANET Device
I	Index (number)
ITS	Intelligent Transportation System
ITSA	Intelligent Traffic Signaling Agent
LD	Lane's on-Duty flag
LP	Lane's Priority
LT	Total Load
LW	Lane's Waiting time
MATLAB	MATrix LABoratory Simulator

MtAA	Message Type ‘AA’
MtAB	Message Type ‘AB’
MtAC	Message Type ‘AC’
MtAD	Message Type ‘AD’
MtAE	Message Type ‘AE’
MtAF	Message Type ‘AF’
MtAG	Message Type ‘AG’
MtAH	Message Type ‘AH’
MtAI	Message Type ‘AI’
NA_R	Northern Approach (to-Right lane)
NA_T	Northern Approach (Through lane)
NM1	First New Method
NM2	Second New Method
PVD	Police VANET Device
Q.L.	Queue Length
RDCS	Road’s Data Collecting System
RSA	Road Segment Agent
RSE	Road Side Equipment
SA_R	Southern Approach (to-Right lane)
SA_T	Southern Approach (Through lane)
SIM_TIM	Simulation Time
T	Time (in Seconds)
TLC	Traffic Light Controller
TLD	Traffic Light Display

VAM	Vehicles Arrival Model
VANET	Vehicular Ad-Hoc Network
VC	Number of Confirmed Vehicles
VDM	Vehicles Departure Model
Vlg	Lagging Vehicles
V_N	Number of Vehicles
VNQB	Number of Vehicles Queuing Behind
VNR	Lane's Vehicles Number Ratio (of the total)
VTNN	Total Number of Vehicle on the Next road
VVD_ID	Vehicle's VANET Device Identification code
W.T.	Waiting Time
WA_R	Western Approach (to-Right lane)
WA_T	Western Approach (Through lane)

NOMENCLATURE

L_D	Lane's on-Duty flag (0: OFF, 1: ON)
L_P	Priority of a Lane.
L_T	Total Load.
L_W	Waiting time for the First Vehicle in a queue.
V_C	Number of Vehicles Confirmed to be arrived to queue.
V_{lg}	Number of Lagging vehicles on a road.
V_N	Total Number of Vehicles entering a lane.
V_{NQB}	Number of Vehicles Queuing on the road Behind in addition to the Vlg.
V_{TNN}	Total Number of Vehicle on the Next road.
C_{FVA}	First vehicle's arrival flag.
I	Lane Index Number ($i \epsilon I$, $I=\{0,1,2,3,4,5,6,7,8,9,10,11\}$)
T	Point of Time
V_C'	Waiting queue length values
V_C''	Queue length values of the Adjacent and not currently green lanes
V_{TC}	Total summation of V_C''
Tx or G_{TNx}	New Green Time for Lane X
VNR-x	Ratio of lane x's Vehicles Number to the summation of the competing queue lengths
GCx	Flag: 1 = Lane X Currently Green, 0 = Lane X Currently NOT Green
GN	New phase Green light index (number)