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운전자의 안전을 위한 도심지역 자동차 애드혹 통신망의 뇌파전송 성능평가

Performance Evaluation of Transmitting Brainwave Signals for Driver's Safety in Urban Area Vehicular Ad-Hoc Network

조준모
동명대학교 전자공학과

Jun-Mo Jo(jun@tu.ac.kr)

요약

최근 U-health 분야에서는 EEG(Electroencephalograph) 뇌파를 전송하여 환자뿐만 아니라 일반 노약자를 대상으로 졸음운전이나 뇌졸중, 또는 심장마비와 같은 위기상황에 대처하기 위해 실시간으로 뇌파를 모니터링하는 시스템을 연구하고 있다. 이러한 시스템은 병원이나 요양원등 다양한 지역에 적용할 수 있다. 본 논문에서는 자동차 통신망에 적용하여 운전자의 뇌파를 실시간으로 모니터링하고 미연에 사고를 방지할 수 있는 통신망 시스템의 성능을 평가하고자 한다. 이를 위해 VANET환경에서 EEG뇌파 전송을 효율적으로 할 수 있도록 옵넷 시뮬레이터에서 제공하는 모바일 애드혹 노드를 사용하였다. 운전자의 뇌파를 노변 기지국으로 전송하는 애드혹한 자동차 통신망을 설계하고 시뮬레이션을 통하여 도심 지역에 적합한 환경을 도출하였다.

■ 중심어 : | 뇌파 | 자동차 애드혹망 | 성능평가 | 의료 |

Abstract

Recently, in the U-health area, there are research related on monitoring brainwaves in real-time for coping with emergent situations like the fatigue driving, cerebral infarction or the heart attack of not only the patients but also the normal elderly folks by transmitting of the EEG(Electroencephalograph). This system could be applied to hospitals or sanatoriums. In this paper, it is applied for the vehicular ad-hoc network to prevent the car accident in advance by monitoring the brainwaves of a driver in real-time. In order to do this, I used mobile ad-hoc nodes supported in the Opnet simulator for the efficient EEG brainwave transmission in the VANET environment. The vehicular ad-hoc networks transmitting the brainwaves to the nearest road-side unit are designed and simulated to draw an efficient and proper vehicular ad-hoc network environment.

■ keyword : | Brainwave | Vehicular Ad-Hoc Network | Performance Evaluation | Medical |

I. Introduction

To improve the quality of healthy life, wireless network technologies are considered as one of the key research areas in computer and healthcare related industries. Especially, the importance of the

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교신저자 : 조준모, e-mail : jun@tu.ac.kr

healthcare technology in the VANET(Vehicular Ad-hoc NETwork) more stressed these days.

Vehicular Ad Hoc Networks are aimed at providing support for safety, traffic management, and comfort applications by enabling vehicle-to-vehicle (V2V) communication or by connecting vehicles to nearby fixed infrastructure. There are several initiatives at the national and international level that are working towards enabling Intelligent Transportation Systems for safety and traffic control applications. Most of these initiatives account for only a certain degree of infrastructure support ubiquitous infrastructure support would require very high cost to deploy, and perhaps even a higher cost to maintain in an operational condition. Hence, the need exists for V2V communication, where a network is constructed in an ad hoc fashion, and no infrastructure is necessary, except for the wireless network interfaces inside vehicles. This creates a very strong argument in using VANET for enabling not only active safety applications, but also in-vehicle comfort and entertainment applications[1].

The pervasive healthcare systems in VANET provide rich contextual information and alerting mechanisms against odd conditions with continuous monitoring. For instance, fatigue in human drivers is a serious cause of road accidents. Hence, it is important to devise methods to detect and quantify the fatigue. There is a paper related to the class of entropy measures on the recorded Electroe nce phalograph (EEG) signals of human subjects for relative qualification of fatigue during driving. These entropy values have been evaluated in the wavelet domain and have been validated using standard subjective measures. Experiments have been designed to test the subjects under simulated driving and actual driving. The EEG signals have been recorded along with subjective assessment of their fatigue levels through standard questionnaire during experiments. The signal analysis steps involve preprocessing, artifact removal, entropy calculation and validation against the subjective assessment. The results show definite patterns of the suggested entropies during different stages of fatigue[2].

In this paper, some vehicular ad-hoc network systems are presented, simulated and evaluated in the point of the EEG signal transmission efficiency in the network. The following chapters are described as follows. Section 2 describes the idea of the EEG, the brainwave, then the common vehicular ad-hoc network system is explained as well. In section 3, the topology of brainwave network for vehicular ad-hoc networks will be depicted. Then in section 4, the suggested networks are simulated in the OPNet simulator and evaluate for the efficient topology of the vehicular ad-hoc network. Finally, the result of the paper is summarized in Sect. 5.

II. EEG Brainwave and Vehicular Ad-hoc Network

2.1 EEG Signal wave

The brain or central nervous system(CNS), produces electrical signals at a variety of frequencies, ranging from DC(direct current) potential shifts to AC(alternating current) frequencies. Early electroencephalographic researchers were limited in their ability to record EEG signals by AC current artifacts and the inability to filter out 60Hz noise precisely. Thus, the EEG was recorded by using simple 'band pass' filters that allowed relatively clean signal detection only below 30Hz, while ignoring signals above that frequency. The EEG is classically composed of four frequency bands:

delta(0-3Hz), theta(4-7Hz), alpha(8-12Hz), and beta(13-24Hz). One can easily remember these bands with a simple pneumonic: "Diet TAB" and remembering only delta and alpha frequencies, allows one to fit the other frequency bands to the pneumonic. Although the EEG is classically described as occurring between 0 and 30Hz, recent work and precise notch digital filtering has defined a gamma frequency greater than 24Hz extending to 50-60Hz[3].

The electrical activity of the brain can be described in spatial scales from the currents within a single dendritic spine to the relatively gross potentials. Neurons, or nerve cells, are electrically active cells that are primarily responsible for carrying out the brain's functions. Neurons create action potentials, which are discrete electrical signals that travel down axons and cause the release of chemical neurotransmitters at the synapse, which is an area of near contact between two neurons. This neurotransmitter then activates a receptor in the dendrite or body of the neuron that is on the other side of the synapse, the post-synaptic neuron. The neurotransmitter, when combined with the receptor, typically causes an electrical current within the dendrite or body of the post-synaptic neuron. Thousands of post-synaptic currents from a single neuron's dendrites and body then sum up to cause the neuron to generate an action potential. This neuron then synapses on other neurons, and so on[4].

[Fig 1] shows an example of 60channels of brainwave obtained from scalp electrodes placed on the head overlying the cortex. Average alpha wave can be peaked to show that an event triggered average of the EEG signal centered on the negative peaks of alpha waves that exceeded a threshold of -50μV in each channel for some typical subject and experiment.

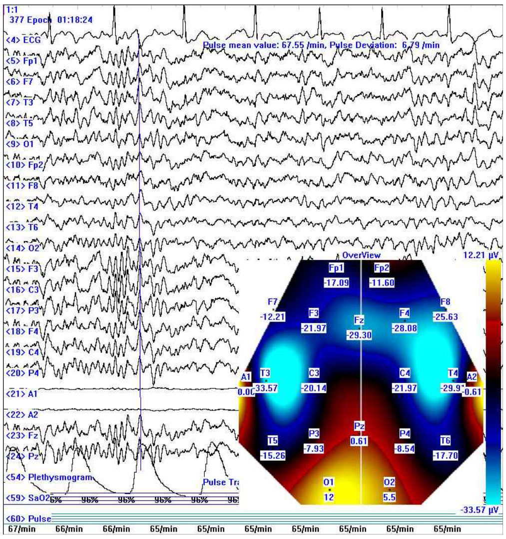

Fig 1. Brainwave Signal Channels

2.2 Transmitting EEG in Vehicular Ad-hoc Network

For the safety on the road, applying EEG monitoring system is considered as one of the key technology in the research laboratory of the major car company as well as international standardization group. In Intelligent Transportation System (ITS) services on-the-road such as Dedicated Short Range Communications(DSRC) for electronic toll collect, WiFi hotspots for traveler and traffic information services, GSM/GPRS/WCDMA cellular networks, Vehicular Ad-hoc Network, and Global Positioning System(GPS) for advanced navigation, route guidance, and vehicular positioning systems. Each system or technology has its own pros and cons. Many technological breakthroughs and innovative solutions are required for each layer and mobility protocol technology shows great promise to enable ubiquitous service access and connectivity for VANET. Mobility protocols aim to maintain end-to-end connections between mobile nodes and their corresponding nodes even if mobile nodes change their points of attachment of the access network.

For example, it is important to investigate if current Mobile IP protocol is suitable for VANET environment since road and safety conditions impose different requirements. Mobile ad-hoc networking technology is important to support car-to-car communications. Ad hoc routing protocol is needed for relaying signals, local alarms, and group-i nterested of information. With these proto cols, VANET users can be served through radio access technologies that better match user terminal capabilities and service requirements while providing efficient use of radio resources[5]. The rapid growth in physiological sensors, low power integrated circuits and wireless communication has enabled a new generation of wireless sensor networks. These wireless networks are used to monitor traffic, crops, infrastructure and health[6].

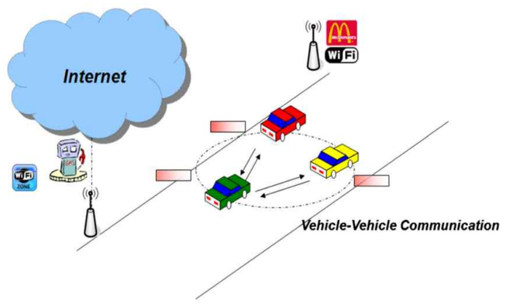

Fig 2. Vehicle/Road-side Communication[7]

In [Fig 2] Vehicles are enabled to communicate among themselves as vehicle-to-vehicle fashion and via roadside access points, vehicle-to-roadside. Vehicular communication is expected to contribute to safer and more efficient roads by providing timely information to drivers, and also to make travel more convenient in a safer way. The integration of V2V and V2R communication is beneficial because V2R provides better service sparse networks and long distance communication, whereas V2V enables direct communication for small to medium distances/areas and at locations where roadside access points are not available[8].

A number of intelligent physiological sensors can be integrated into a VANET, which can be used for computer assisted anomaly detection and medical conditions.

The implanted brainwave sensors in a car will collect odd signal changes in order to monitor the driver's health status no matter their location on the road. Not the selected signals but the whole detected brainwaves will be sent to the main server. If an emergency is detected, the on-board unit(OBU) in the car immediately warns the driver and protecting from dangerous situation like drowsiness or medical emergency.

III. Designing of EEG Vehicular Ad-hoc Network

In the Opnet simulator, there is no VANET node to use, so I had to use the Mobile Ad hoc NETworks (MANET) node with mobility function. The MANET is a group of wireless mobile nodes that have no fixed infrastructure. Therefore each node can act as a router or an end-user node. So the node operates exactly the same as the VANET node. Then the EEG function and specifications are applied to the node for the VANET environment.

The topology of the EEG VANET suggested in this paper is as follows. The VANET environment is a width of 100km and height of 2km. There are many or a few vehicles running in 20km/h or 60km/h speed on the urban area road. The road is either bi-directional 2 or 4 lanes. The width of the road is similar with the common road in a city. For instance, as shown in Fig. 3, there are a few cars running in 60km/h on a bi-directional 4 lanes of a road. The upper 2 lanes of cars are the 'right-to-left' direction and the lower 2 lanes of cars are the 'left-to-right' direction.

The collected EEG data from a mobile node, for instance, the 'mobile_node_27', sends it to the road-side-unit, the node_0, since not all nodes send EEG data to the server. There about 60 channels are specified for EEG device as mentioned earlier, generally only few channels are used for checking critical conditions for the patients. So I consider only 15 channels of EEG detector and the total sample rates are set to 10,000bit/s. Then the mobile node tries to send to the road-side-unit. Each mobile node has 300m radius signal propagation capacity. So a mobile node is out of the communication parameter from the road-side-unit, the adjacent nodes could help to propagate the EEG signal. After that, whenever the server gets the signals from the road-side-unit through the common networks such as wi-bro or the Internet, it examines the brainwave for the odd symptoms and alerting the situation in realtime. However, just this part is omitted in this Opnet simulation.

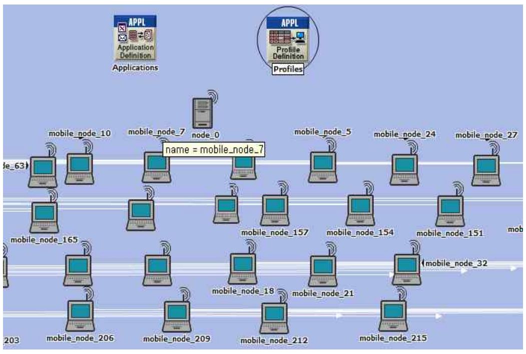

Fig 3. Topology of the EEG VANET

IV. EEG VANET Performance Review

4.1 Simulation Types of EEG VANET Environment

As described in the previous section, there are some parameters to specify for the simulation. Therefore, 6 types of simulation environment are designed and simulated. Every environment is bi-directional road, so I omit the part of the specification name. The network types are as follows: a '2-lane 20km(few)', a '2-lane 20km(many)', a '2-lane 60km(few)', a '2-lane 60km(many)', a '4-lane 20km(few)', and a '4-lane 20km(many)' a '4-lane 60km(few)', and a '4-lane 60km(many)'. For instance, a '2-lane 20km(few)' means that there are a few cars run in 20km/h on a bi-directional 2 lanes. And, a 4-lane 60km(many) means that there are many cars run in 60km/h on a bi-directional 4 lanes. I assume that the suggested EEG VANET environment is for urban region, so there are at least a few cars on the road in any suggested environments.

4.2 Performance Evaluation

In [Fig 4] the throughput of the '2-lane 20 km(few)', and the '2-lane 20km(many)' are compared. The throughput of '2-lane 20km(many)' decreases for a short period of time at 14 minutes but it come back at once. The throughput of '2-lane 20km(few)' decreases at 16minutes because of few cars on the road. However, the both throughput are considered as fairly good and they don't have much difference on the performance. Hence, the number of the car doesn't affect great deal for the performance in the urban EEG VANET area environment. At the point of view, the result seems relevant with other results of the environments as well.

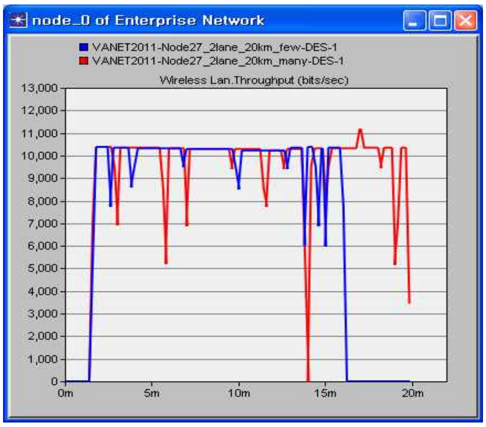

Fig 4. Throughput of '2-lane_20km's

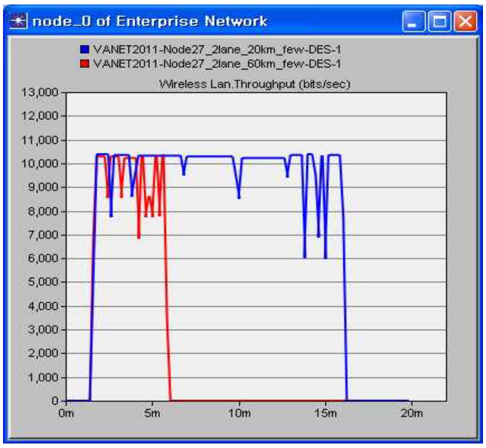

Fig 5. Throughput of '2-lane(few)'s

In [Fig 5] the throughput of the '2-lane 20km (few)', and the '2-lane 60km(few)' are compared. The cars in the '2-lane 60km(few)' move much faster than the cars of the other environment. So it is obvious that the throughput of '2-lane 20km(few)' is better than the other. As we can see in the graph, the throughput of the '2-lane 20km(few)' showed fairly good performance, but the throughput of the '2-lane 60km(few)' is decreased severly after 6 minutes from the simulation.

In [Fig 6] the throughput of the '2-lane 60km (few)', and the '4-lane 60km(few)' are compared. The throughput result show that '4-lane 60km(few)' is better than the 2-lane environment. The result is similar with the throughput of '2-lane 20km(few)', and the '4-lane 20km(few)'.

[Fig 6] shows that the throughput of the '2-lane 20km(many)', and the '4-lane 20km(few)'. The performance of 4-lane also showed better than the 2-lane even though the 2-lane environment has many more cars on the road.

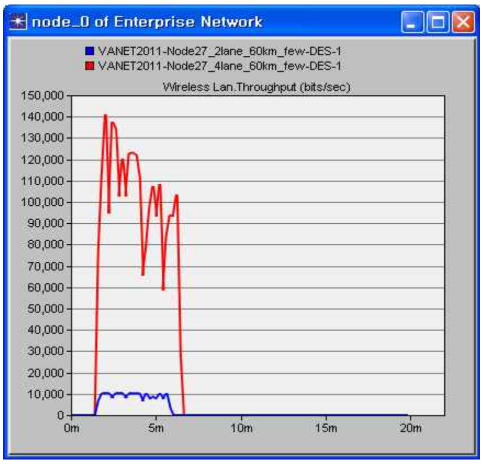

Fig 6. Throughput of '60km(few)'s

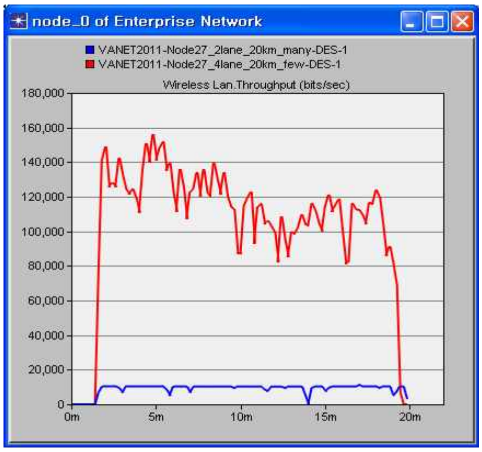

Fig 7. Throughput of '20km's

For the conclusion, firstly, the speed of the car in the networks affects the performance gradually.

Moreover, as shown in [Fig 4] [Fig 6] and [Fig 7] the number of car doesn't affect the great deal of performance. Therefore, the significant factor to influence on the entire EEG VANET environment is not the number of car but the number of lane in the urban area network. Hence, the result show that the other moving direction of the cars didn't do much help to propagate the EEG data, but the cars moving same direction on the next lane give much help instead of having only one lane.

V. Conclusion

The safety of the car technology is a vital in automobile industry. So I have designed and simulated the EEG VANET environment that monitors the driver's EEG data to prevent dangerous situations and warn him or her.

To find out an efficient EEG VANET environment, I have designed simulated the 6 types of the network. With the simulation results, I found out that the speed of the car in the networks affects the performance gradually. And the significant factor to influence on the entire EEG VANET environment is not the number of car but the number of lane in the urban area network. In fact, the other moving direction of the cars didn't do much help to propagate the EEG data, but the cars moving same direction on the next lane give much help instead of having only one lane. For the further study, the EEG VANET environment is need to applied in the various road environments such as cross road, circular or interchange area.

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저 자 소 개

조 준 모(Jun-Mo Jo) 정회원

▪ 1991년 1월 : Iowa State University Computer Science 졸업(학사)

▪ 1995년 2월 : 경북대학교 컴퓨터공학과 졸업(석사)

▪ 2004년 2월 : 경북대학교 컴퓨터공학과 졸업(박사)

▪ 1998년 3월 ~ 현재 : 동명대학교 전자공학과 부교수

<관심 분야> : 애드혹 센서망, VANET, 지능형교통시스템(ITS), 뇌파전송