Risk prediction system based on MIMO system for vehicle users

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Abstract: Vehicle users are facing a number of health problems, which create complicated situations. Some cases are very serious in which the road accidents create fetal or long term disabilities. Risk prediction systems (RPS) and health monitoring systems (HMS) have been used for a number of e-Health applications, which are basics to some serious diseases. In this paper, tiredness while driving (TWD) is considered as a risk, which is indications of some symptoms caused in the drivers' health while they are driving. Efficient communication of RPS is the challenging problem because TWD is dangerous to all other drivers. Here, health related problems including tiredness are notified to driver who is becoming tired through the efficient RPS. In this novel approach, RPS should provide accurate information for each symptom created from any disease which creates the tiredness. So, we have decided to use multiple-input, multiple-output (MIMO) system, which enhances the efficiency of communication and accuracy of the correct reaction monitored from body. Also it provides less energy consumption, which reduces overall cost. In this MIMO system, feedback and computation of quantization considered as Pn-manifold provide better rates, resolution and spectrum during the communication than the existing systems.
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1 Introduction

The driver who is getting tired would not know what he thinks and where he drives. Basically, driver becomes unconscious and he needs some sort of warning system, which helps him to make a safe driving. To keep necessary precaution during the driving, TWD should be automated through the proper warning system. RPS needs efficient communication, which provides better information and quick responses when symptoms are identified. In order to analyze the efficiency of communication and accuracy of the RPS, MIMO system will be one of the best solutions. In this proposal, efficiency and accuracy of risk prediction involved with communication are investigated and analyzed. In this analysis, errors of the risk predictions are minimized because resolutions are increased with new techniques, which uses MIMO channel with feedback and Pn-manifold [14]. The Pn-manifold is used for quantization, which determines the rates of the feedback categorized into two forms. They are infinite and finite rate feedback but available rates for practical MIMO is considered between these two rates.

A basic MIMO configuration has two transmitters and two receivers, but it can have N transmitters and M receivers. Many wireless LAN (WLAN) devices used in E-Health applications [1-4] employ N×M configuration of N = 2 and M = 3. The MIMO system transmits the information of risk prediction over multiple channels. Regarding the E-Health applications, this technology can now be used in a wide range of medical communication devices including mobile phones, PDAs and laptops. In this proposal, the greatest testing challenge for MIMO systems involves with feedback and Pn-manifold, which provides less energy consumption, better spectrum and resolution during the transmission than the legacy systems. RPS needs efficiency when multiple risks are analyzed with some form priority order. Regarding the risk prediction communication, transmission of multiple signals requires efficient communication and accurate synchronization.

Using a MIMO communication in which TWD is causing the serious problem, there are three ways to handle the RPS from the moving vehicles. First is the spatial multiplexing technique, which transmits the different risk prediction information on each channel. Here, throughput is increased. Second is spatial diversity technique, which transmits the same risk prediction information on each channel. Finally, beam forming technique, which improves the throughput and coverage by limiting the directionality and the shape of the transmitted signal.

2 Health Monitoring and Diagnostic System

Monitoring and diagnostic systems controlled through remote mode and other wireless facilities are necessary because TWD within the remote areas need to be identified. So, this HMS and RPS will help them whenever and wherever they drive. Using these new technologies, drivers are not only protected from the unnecessary accidents but also they enjoy life with all latest medical facilities such as quick prescriptions,

medical cost, etc. Wearable health monitoring systems are better for elders because HMS and RPS are fitted with the jacket or coat. So, it can observe all real-time risks caused by a medical condition of the driver and it can be monitored using sensors which are either bio or chemical sensors. These sensors can be implanted within the human body or attached with jacket which is easy to handle during the driving. Wearable approach of RPS and HMS is also available to monitor the risks caused during the travelling. Through the Pn-manifold techniques, capacity of MIMO channel can be enhanced and energy consumption can be reduced [8, 9].

2.1 Risk prediction without any contacts

Sensors and molecular communication can provide an interesting novel technique to future RPS [5, 17]. Some biosensors and molecules selected in each cell of the human body have some mutual power in order to exchange information. This power or energy between these points (biosensor and the molecule) is detectable through the dedicated sensors. The power or energy variation should be compared with the average person (100% medically fit) and sick person. We can have tolerance levels for individual cell depended on the disease and other environmental factors, which could be added as overall noise for future development. The molecules used in these biosensors can be affected by the external environmental changes such as temperature differences and the direct sun light. Table 1 shows the example of risk predictions for TWD based on previous medical history and current reactions of eye ball during the driving.

Table 1: Risk predictions for tiredness based on eye ball reactions

Code	Risk predictions	Symptoms, accidents and potential injuries/ diseases
1	Eye ball size	Average measurement, actual size, new size during the driving
2	Eye pressure	Normal and abnormal pressure
3	Eye infection	Basic symptoms and driving conditions for eye infections
4	Eye sight for patients with Type 1 diabetes	Basic symptoms for type 1
5	Eye sight for patients with Type 2 diabetes	Basic symptoms for type 2

2.2 Risk prediction for vehicle users

Tiredness is one of the serious problems when people are driving for a long time. TWD is a common problem in western countries including UK and USA but it can be controlled with modern technology, which is updating all necessary information about the status of the driver during the driving. Without any obstructions, vehicles equipped with HMS passes the updated information to the nearest centre, which is responsible to take the quick action before the accident. There are many methods, which can be used to proceed in order to reduce the problems such as environmental conditions that increase the TWD and affect the driver and passengers. Following solutions are expected to investigate in real applications; Automatic slowdown mechanism when tiredness is detected can be applied using sensors which provide quick response through the HMS.

Warning lights or signals for other drivers who are closed to which vehicle is about to stop for emergency. Drivers with strange behaviour like drink and drive or other unusual conditions will be spotted through this system which provides extra safety on the roads.

2.3 Measurements of risk monitoring

Relevant information for measuring tiredness should be recorded and tested. This measurement provides us to design an accurate health monitoring system. Following measurements have to be considered. Eye ball measurement before and after the tiredness Temperature variation inside the vehicles Medical conditions which affect the long distance driving.

2.3.1 Eye ball measurement before and after the tiredness

It is an important measurement for which people are driving for a long time continuously. Long distance driving for a long time without regular stop will change the behaviour of the body and increase TWD. When eye ball measurement is exceeding the threshold, risk is identified and sent through the MIMO channel.

According to [16], the eye ball and statistical analysis of eyeball protrusion are investigated for monitoring tiredness. In this study, protrusion is considered as symptoms of tiredness or other eye infections, which can be observed through the sensors equipped within the vehicles. Some measurements have to be observed medically they are such as eye ball size and eye ball positions. Eye ball protrusion (E_p) can be calculated from (1) as given in [16], which has more information about these measurements.

$$E_p = \alpha - \beta \times O_d \quad (1)$$

Here, constants α and β are 18.3 and 0.4 respectively. Orbit depth (O_d) should be measured

using appropriate sensors. Finding optical axis and eye ball positions are bit complicated but these measurements can be optimized as in [18]. Using optical or bio sensors, all necessary measurements can be calculated for finding expected risks (TWD) and sent through the MIMO communication channel as shown in figure 1.

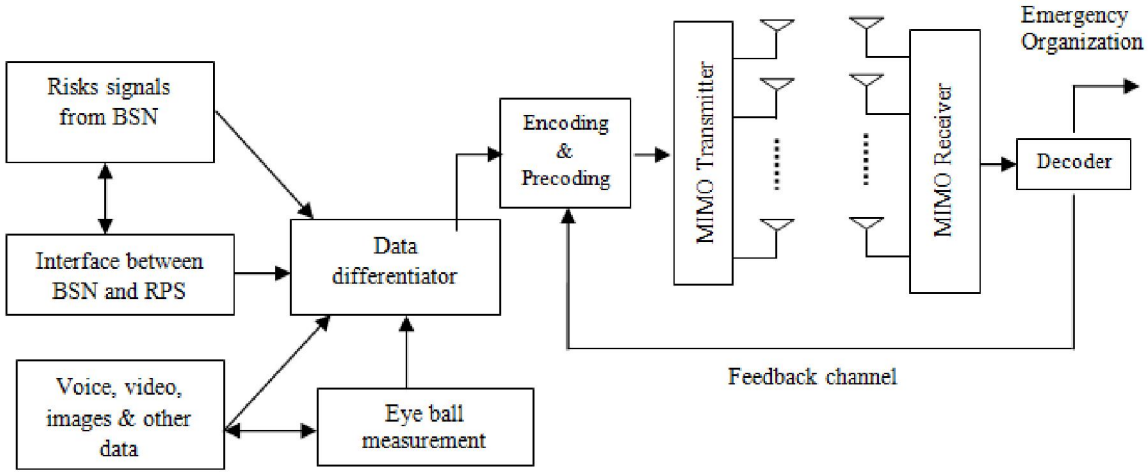

*Figure 1 RPS with MIMO communicati*on

2.3.2 Temperature variation inside the vehicles

Heating system must be controlled according to the driver who faces some specific problems, which include all medical conditions, environmental conditions and other factors. There must be automatic adjustments for long distance travelling. Constant heating also is not good for a long time because it will make nice environments for sleeping. Engine heating and other heating related problems inside the vehicles must be checked because it will create uncomfortable situations [19].

2.3.3 Medical conditions which affect the long distance driving

Obstructive Sleep Apnoea (OSA) is the worst case in which people are driving for a long time. It is one of the sleep related problems, which increase the TWD and accidents. This medical disorder needs to be monitored and identified during the driving if the person or driver is not arranged any precautions before the driving.

It is one of the examples in which people with OSA need full treatments and good sleep before driving. In this situation, breathing must be regulated using modern technology. The Continuous Positive Airway Pressure (CPAP) is used for this treatment, which helps the patient to regulate breathing. In order to use CPAP, a soft face mask should be worn during the sleep, which controls the OSA. This treatment improves the patients' concentration and reduces the day-time sleepiness and TWD.

3 Theoretical Model of RPS Based on MIMO

In this model, risk prediction [13][17], health monitoring and other diagnostic systems based on MIMO are considered as shown in figure 1. Modern vehicles equipped with sensor nodes and mobile network based on MIMO mobile stations need to be protected from unnecessary accidents. The vehicles which are on the move can use RPS and sensors to exchange data between the human body and RPS. In order to make a quick transmission, MIMO technology is applied using manifolds, which increase the capacity and power. In this case, VANETs can also be used in Body Sensor Networks (BSNs) through the MIMO channel.

Application of RPS in which people are driving on the road, is very challengeable because communication between RPS and emergency organizations such as healthcare, accidental care, road side unit (RSU) etc. should be perfect and accurate. Situation where moving vehicles through the environmental conditions may not be easy to use RPS for TWD. Here, MIMO with feedback provides necessary support to increase the efficiency of communication. Following problems have been analyzed in this risk RPS.

3.1 Overhead problems

According to features and channels used within the vehicle, transmitting and receiving antennas are increased in MIMO technology. These antennas increase the hardware cost and complexity which

means that hardware overhead of this technology should be controlled through the Pn-Manifold. Matrices used in the Pn-manifold can be optimized to reduce the size of the MIMO channel matrix and its rank [6][14].

3.2 Pn-Manifold

In this paper, we show that overhead problems and solutions for RPS are controlled by new MIMO technology, which uses Pn-manifolds. As mentioned in [14], sets of positive semi-definite matrices are considered to identify the Pn-manifold with various trace and ranks, which optimize the overall problems. Depending on the system constraints however, we shall classify the space of non-negative matrices into four categories.

Classification of 8 different manifolds obtained from covariance matrices can be considered as Pn-manifolds. They are given below;

First category

1. Matrix size (positive integer)

Second category

2. Elemental field (obtained from field $\mathbb{F}$)
3. Elemental field (real values $\mathbb{R}$)
4. Elemental field (complex values $\mathbb{C}$)

Third category

5. Trace constraint $Tr(Q) \le \rho^2$
6. Trace constraint $Tr(Q) = \rho^2$

Fourth category

7. Rank constraint $Rk(Q) \le s^2$
8. Rank constraint $Rk(Q) = s^2$

Using following example, original set (2) and short form representation (3) of Pn-manifold are given below.

$$set\{Q \in C^{4\times 4} | tr(Q) \le 1, rk(Q) = 2\} \quad (2)$$

$$P(4, \mathbb{C}, \le 1, = 2) \quad (3)$$

Regarding the TWD situation, following representations of Pn-manifolds are examples of real and complex form used in MIMO technology, which provides a number of advantages in RPS developments.

$$P(p, \mathrm{R}, \le \rho^2, = k)$$

$$P(p, C, \le \rho^2, = k)$$

Consider a 3x3 MIMO channel model as $y = Hx + n$, where the input and output are x and y respectively. In this, channel matrix H is considered between the transmitting antennas of body signals and receiving antennas of RPS and emergency organization. Noise n is added with channel during the driving. In the conventional application, short-term power constraint (STPC) is used alone but currently both STPC and long-term power constraint (LTPC) are handled using Pn-manifolds.

The channel state information and feedback are used to calculate the available useful rate C_{CSI-Fb} of the system as in (4). Receiver of MIMO computes optimum covariance matrix Q_{opt} corresponding to the available H and sends back to the transmitter through the feedback.

$$C_{CSI-Fb} \triangleq E_H log_{10} \det(I + H_q(Q_{opt})H^H) \quad (4)$$

where I, H_q and E_H represents the identity matrix, quantized H and usual expectation over the ensemble of H matrices respectively.

$$D(w) = E_H\left[\lambda_1 - \max_{\omega \in w} \sum_i \lambda_i |v_i^H \omega|^2\right] \quad (5)$$

In order to measure the accuracy of the RPS, the distortion measurement $D(w)$, which affects the overall performance can be optimized using Pn-manifold. In equation (5), w is the projection codebook and value λ_1 is the largest value of the $H^H H$. The power efficiency factor μ is bounded as

$$\mu \gtrsim 1 - d.2^{-\frac{N_f}{N}} \quad (6)$$

In (6), N, N_f and d being the dimension, bits per feedback index and distance between any two points on the Pn manifold chosen for quantizing Q_q. Pn manifold is used for quantization, which determines the feedback rates C_{CSI-Fb} as in (4). The quality of feedback depends on the number of bits used in the codebook, which is the representation of quantization created from Pn-manifolds.

Using MIMO technology with Pn-manifolds, the efficiency (rate) of the overall RPS, speed of responses, accuracy and energy consumption can be optimized. In order to pass the TWD quickly and accurately, we have considered the rate changes for different SNR analyzed in next section.

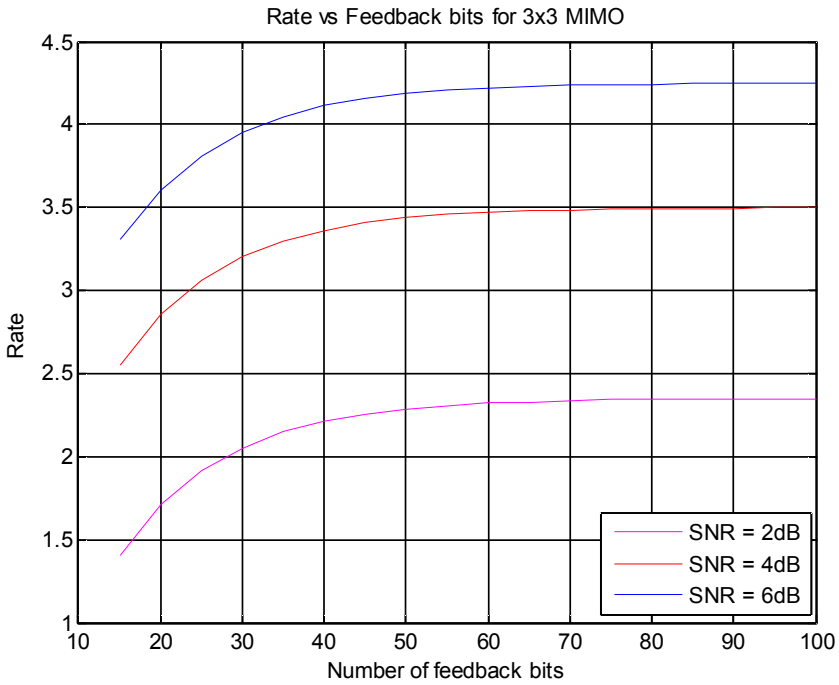

Figure 2 Rate vs feedback bits for 3x3 MIMO system with three different SNR values [14]

4 Results and Analysis

MIMO with feedback will be designed for minimizing overall power and complexity which is very important to reduce the cost and increase the accuracy in TWD.

According to [14], figure 2 is obtained for different SNR values, which is very useful for fast fading case. Detail information of Pn-manifold can be obtained from [14], which the energy consumption and complexity reduction using Pn-manifold are considered.

In this result and analysis, consider a MIMO fast fading link with $N_t = 3$ transmitting and $N_r = 3$ receiving antennas, which collect all the symptoms from the body. It means that an individual risk is transmitted to emergency organization or RSU through the MIMO channel, which uses the feedback. Channel capacity should be increased through which the analysis of power based on Pn-manifold is being optimized with feedback bits.

4.1 Capacity

In RPS based on MIMO system, capacity □ □ and feedback rates are characterized by the dimensions of the manifold, which is corresponding to H matrix and its rank.

$$C_p = \sum_{i=1}^{v} \log\left(1 + \frac{\rho}{N_t}\lambda_i\right) \qquad (7)$$

In (7), $(\lambda_1, \lambda_2 .... \lambda_v)$ are the positive eigenvalues known as the square of the non-zero singular values of the channel matrix. Here, the constant □ is the signal to noise ratio at each receiver antenna.

4.2 Overall cost

The complexity of the system increases the overall cost, which covers computation of all hardware and software of RPS. In order to enhance the accuracy of monitoring when RPS is practically employed in TWD which is one of the e-Health applications, MIMO design [9], which uses Pn-manifold with feedback will be considered. The RPS should be able to handle multiple rates when different e-Health applications including TWD are monitored in different environments [4][5]. From the analysis of previous research and investigations of papers, rates and other parameters, related to improve the RPS will be considered to increase the efficiency of communication and accuracy of the monitoring. In the analysis of RPS based on MIMO channel, less energy consumption, better resolution and spectrum during the communication related to risk prediction information are expected.

5 Solutions for preventing accidents related to tiredness

There are some solutions available for drivers who really face one or more problems mentioned in Section 2. Automatic, dynamic and natural solutions can be used but natural solutions are always useful. In

the modern busy world, natural solutions are not practical to achieve the targets within which a number of conditions are being used. So, we will focus other two solutions, which provide quick and accurate responses through MIMO technology when drivers are about to force themselves beyond the limit.

5.1 Automatic solutions

Alarms are used for this situation where thresholds of upper and lower limits are programmed. This automatic alert will encourage the drivers and prevent them from unnecessary accidents.

5.2 Dynamic solutions

In this approach, drivers will be alert because the alert message is sent from RSU or emergency organization. Moment that drivers about to feel sleepy or tiredness and reaching nearest resting location is monitored and RPS attached within the vehicles is designed with many features such as data management, user interaction, and remote session management. Dynamic solution which creates from the proxy server or agent located in managed devices are processed when vehicles are moving Diagnostic and HMS is also functioning to generate the dynamic solution for a quick decision. Sensors that measure the details of eye ball, temperature and other initial conditions are employed in RPS, which communicates in real-time and provides instance solutions through the MIMO network [7].

Human recorder system (HRS), that gathers health information of drivers and passengers transmit it wirelessly to a mobile phone or PC. Remote monitoring of bio-signals is also recorded dynamically and provides necessary action through the MIMO network. Triple-axis sensors and bio-sensors are used to measure human movements within the vehicles and body surface temperature respectively [11,12]. Using HRS, stress levels, eye ball movements, levels of tiredness and heartbeat fluctuations can be gathered, recorded and transmitted dynamically to a RSU or emergency organization.

Discussion and Recommendations

In this section, future RPS, HRS and HMS within the vehicles, next generation technology in vehicle communication and driving conditions with maximum safety standard are considered. Technology is being updated with new features which help us to monitor our health while we are on the move. In the next generation technology, MIMO system will dominate in a number of applications such as health prediction system, safety alarm for quick responses etc.

Wearable jacket which holds many sensors can be used to detect the health problems [10]. These sensors are able to collect all sensible signals and necessary information assumed to be input data for MIMO system. In the next generation technology, the role of the MIMO will be countless because future MIMO is not only efficient technology but also it will reduce the cost and complexity. It means that it can fit into any medical devices which are currently available for the healthcare system. Adaptive antenna using MIMO technology can be proposed for measuring precise details of signal quality and quantity of heartbeat fluctuations. Further, calibration procedures will be generated and compensated precisely for all temperature variations.

Conclusions

In this paper, solutions used for TWD, medical and driving protections, are studied with MIMO schemes. From these solutions, health condition of the driver is monitored efficiently through the HMS or RPS and passed on other potential drivers quickly through the MIMO communication. Further, this system will reduce the overall cost of the road safety, death toll and traffic. Tiredness which increases sleeping ability without drivers' knowledge kills many people per year in all over the world. As a first solution, when drivers prepare for driving, instance warning is reminded again that you are eligible to drive or not. Driver's health conditions during the driving can also be monitored. Further, when elders are driving, this system will help us more in all environments.

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