TEKNOFEST

AEROSPACE AND TECHNOLOGY FESTIVAL

TECHNOLOGY FOR HUMANITY COMPETITION

PROJECT DETAIL REPORT

PROJECT CATEGORY:

Social Innovation

GRADE

Gyroscope and Accelerometer System Integrated with Vehicles

MERAKI

#69644

TEAM LEVEL:

University-Graduate

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1. Project Summary

The use of motorized vehicles, especially on uphill or downhill roads such as in mountainous areas, increases the risk of accidents, so drivers must be very careful when driving. The main purpose of this system is to automatically prevent vehicles from descending uncontrollably while driving downhill by controlling transmission, engine rpm, and engaging engine brake, rather than using conventional braking methods. Before taking action the vehicle must know its orientation and inclination, this is done by integrating the accelerometer and gyroscope MEMS (Micro-Electromechanical System) sensor directly into the ECU (Engine Control Unit). Inclination data from the accelerometer MEMS sensor can also be used to turn on uphill start assist when it detects the vehicle is stationary in ascending position. This assist system is expected to increase automatic transmission vehicle safety and reduce accidents involving conventional brake failure in mountainous regions. Figure 1 shows the position of the gyroscope and accelerometer sensors on a vehicle that can detect 3 axes.

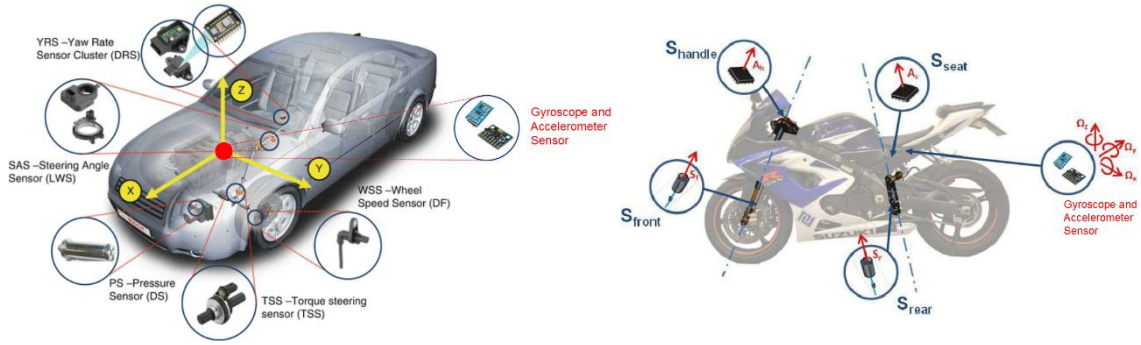

Figure 1. Gyroscope and Accelerometer Sensors in Vehicles

GRADE or Gyroscope and Accelerometer System Integrated with Vehicles is a solution that can help drivers, especially those who drive on roads that have a certain slope. The integration of gyroscope and accelerometer sensors on vehicles is carried out by remapping processes and programming the vehicle's ECU to be able to activate the sensor output so as to maintain vehicle stability automatically, especially when on certain road slope conditions. By integrating the automatic control system, GRADE can maintain the safety and comfort of the rider.

2. Problem

The existence of geographical conditions and road routes such as: inclines, descents, and winding roads greatly affect the level of security and safety for rider safety, especially in mountainous areas. Reporting from Suara.com., the construction of winding roads in the mountains helps motorized vehicles to drive easier because generally they are not strong enough to go through steep inclines with long enough distances to exhaust a lot of energy.

Based on data from the National Transportation Safety Committee (KNKT), the location of the largest road traffic accident in Indonesia is in the densely populated island of Java, which is occupied by West Java Province with hilly, mountainous geographical conditions with inclines, descents, and winding roads as shown in figure 2.

Figure 2. One of the Road Conditions in West Java, Indonesia that is Prone to Being Passed
(*resource*: Youtube.com)

Figure 3. One of the Road Conditions in Nagano Prefecture that is Prone to Vehicles
(*resource:* japanesestation.com)

In addition, the number of fatalities of traffic accident in Nagano Prefecture, the region with the highest altitude of residence area in the whole of Japan in 2017 is 79, which is not so many but has been almost constant since 2012. Figure 3 shows the road conditions in Nagano prefecture. This is a global problem that needs to be resolved. Applying the brakes for a long time heats the brake discs, heated disc reduces the stopping ability. This is not a problem in manual transmission vehicles where the driver can lower the gear ratio and slow down the vehicle. Manually changing gear ratio can't be done in automatic vehicles so the driver must use conventional braking. Frequent braking causes the

disc to warm up and can result in a complete loss of stopping ability (brake failure) and result in an unavoidable accident.

3. Solution

GRADE or Gyroscope and Accelerometer System Integrated with Vehicles help drivers, especially those who drive on roads that have a certain slope like hills and mountains with various road conditions. The integration of gyroscope and accelerometer sensors on vehicles is carried out by remapping processes and programming the vehicle's ECU to be able to activate the sensor output so as to maintain vehicle stability automatically. The system on the vehicle is optimized especially on uneven roads and has inclines, descents or winding roads to provide safety travel results for the driver. The vehicle input system in the form of a gyroscope and accelerometer sensor which is placed the threshold angle with a program connected to the ECU so that the program can perform calculations on the angle of inclination and acceleration. The calculation results will be processed and produce output through Automatic Transmission Fluid (ATF) which is associated with the torque converter, hydraulic control unit and planetary gear unit, thus providing automatic calculation results as the output of the integrated gyroscope and accelerometer sensor calculations. The work process flow of the system is shown in Figure 4. By integrating the automatic control system, GRADE can maintain the safety and comfort of the rider and make traveling on inclines, descents and bends easier.

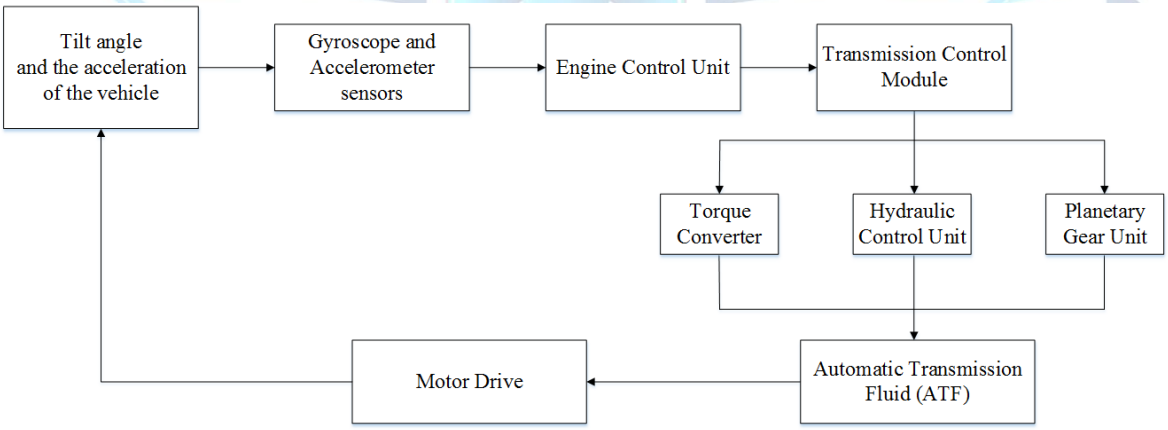

Figure 4. The Work Process Flow of the GRADE System

4. Method

Accelerometer and gyroscope MEMS sensor data is constantly collected to determine the vehicle current inclination. When vehicle inclination calculated from the sensor data passes a certain threshold angle, it automatically turns on the assist system. When the vehicle descends in an angle greater than the threshold angle, the system calculates the descent acceleration experienced by the vehicle. The system's main function is to negate the descent acceleration caused by earth’s gravity by creating an intentional resistance inside the engine. At the same time the system lowers the power input from the driver acceleration pedal, both actions make it possible that even though the vehicle is descending it behaves as if it were

on a flat road. Both the resistance inside the engine and power input lowering effects are linearly proportional to the descent acceleration experienced by the vehicle. The system can change the transmission to lower gear when the actions that are already performed is not enough to slow down the vehicle.

Second function of this system activates if the vehicle stops in an ascending position with angle greater than the threshold angle. When this condition is fulfilled the system automatically turns on the uphill start assist which prevents the vehicle from descending backwards when the brake pedal is released by the driver. Brake is released when the car forward acceleration is greater than backward descent acceleration caused by earth's gravity.

Both sensors can also be applicated in motorcycle system as well. Suppose that the motorcycle is tilted sideways (taking turn) and the throttle is zero, if the angle is greater than the threshold angle the system will prevent disconnection between the engine and the wheel to avoid skidding when sudden brake is applied by the driver. Figure 5 shows the position of the gyroscope and accelerometer sensors on a vehicle that can detect 3 axes and figure 6 shows a vehicles that is integrated with the GRADE system and programs area working on the vehicles.

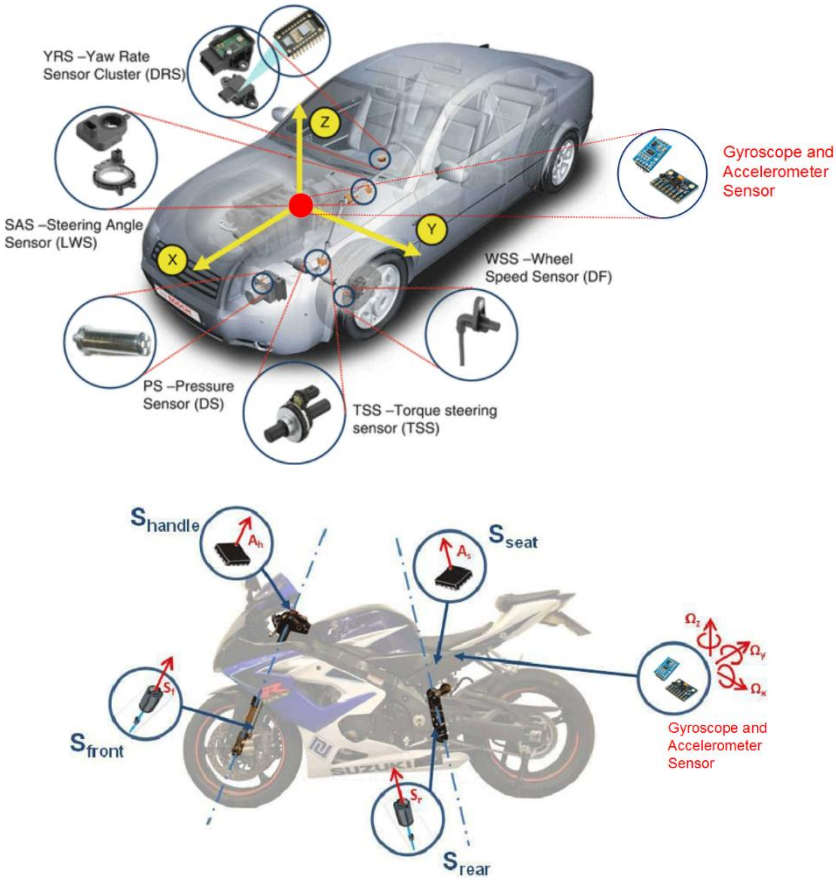

Figure 5. Gyroscope and Accelerometer Sensors in Vehicles (Car and Motorcycles)

Figure 6. Vehicles that is Integrated with the GRADE System and Programs Area Working on the Vehicles

5. Innovative Aspect

The accelerometer has the ability to measure the gravitational acceleration on each axis to determine the slope of the vehicle flow, then data is sent to the ECU which is used to control engine speed and transmission. Action taken by the ECU to slow down the vehicle differs depending on the vehicle inclination from the current position on the road. Based on the analysis, in the community, the gyroscope sensor system has been integrated on certain motorcycles, however, the integration has not been optimal for the driver and vehicle. GRADE is a system that has been developed more optimally and has never been made by anyone else so that the authenticity of GRADE can be recognized both on motorcycles and cars as vehicles that are widely used in society. By developing the ECU program using a remapping process supported by programming on the gyroscope and accelerometer sensors using an arduino microcontroller, GRADE will improve driver safety and comfort while driving.

6. Applicability

GRADE integrated into the vehicle will increase the safety of the driver in driving will be very useful for the community, especially for those who drive on inclines, derivatives, winding roads or areas with varying geographical conditions. Through a process of further research and testing, GRADE will be able to be implemented on vehicles and is expected to be installed on large numbers of vehicles and become a commercial product, both on cars and motorcycles to support driving safety. The risk that may be found is that the driver's experience in driving becomes less reliable, especially if the driver drives using a manual

vehicle that has not used the GRADE system, so the driver needs to be careful when driving. However, this can be avoided if the GRADE system can be optimally implemented on large-scale and targeted vehicles

7. Estimated Cost and Project Time Planning

7.1 Estimated Cost

In this section, the project budget is created based on prototype implementation to support the project's pilot program to completion and actual implementation estimates using existing vehicles in the community.

7.1.1 GRADE Prototype Project Budget

Table 1. GRADE Prototype Project Budget

No.	Item	Quantity	Unit price (USD)	Total Price (USD)
1	3 Axis digital accelerometer sensor module	1	6.89	6.89
2	3 Axis digital gyroscope sensor module	1	6.89	6.89
3	Arduino microcontroller	1	10.33	10.33
4	ECU Remap Tool	1	241.25	241.25
5	ECU connector cable	1	13.78	13.78
6	ECU System Software	1	344.07	344.07
7	Power supply	1	13.78	13.78
8	Adaptor	1	13.78	13.78
9	Vehicle ECU	1	516.79	516.79
10	Prototype Frame	1	68.90	68.90
Total (USD)				1236.46

7.1.2 GRADE Real Project Budget

Table 2. GRADE Real Project Budget

No.	Item	Quantity	Unit price (USD)	Total Price (USD)
1	3 Axis digital accelerometer sensor module	1	6.89	6.89
2	3 Axis digital gyroscope sensor module	1	6.89	6.89
3	Arduino microcontroller	1	10.33	10.33
4	ECU Remap Tool Full Set	1	551.42	551.42
5	ECU connector cable	1	13.78	13.78
6	ECU System Software	1	344.07	344.07
7	Power supply	1	13.78	13.78
8	Adaptor	1	13.78	13.78
9	Computer set	1	551.42	551.42
10	Component installation costs	1	193.00	193.00
Total (USD)				1705.36

7.2 Project Calendar

Table 3. Project Calendar

No	Activity	Month		
		1	2	3
1	Identify needs, existing study, determination of product specifications, concept design, selection of concepts			
2	Numerical analysis, gyroscope sensor design, digital prototyping, detail drawing			
3	Designing manufacturing and assembly processes, cost calculation			
4	Manufacture and testing of prototypes, evaluation and re-design, reporting			

8. Target Audience of Project Idea (Users)

Vehicle integrated with accelerometer and gyroscope MEMS sensor are safer than conventional vehicles and suitable for people who mobilize in areas that are dominated by hills and mountains with various road conditions that can be dangerous for the driver and passengers, so, the vehicles with an injection system can run more safely and comfortably on a variety of road conditions, whether on an incline, descent, or bend. In addition, the automatic system can be deactivated when driving on flat roads, so GRADE can be applied to various vehicles and is used by drivers both on flat areas and with geographical conditions that vary with uphill, downhill, or bends. It can help people, especially in the social aspects of innovation.

9. Risks

For the GRADE project, the risk of problems that may arise is shown in the form of a probability and impact matrix as shown in table 4.

Table 4. The probability and impact matrix

Likelyhood	Consequences				
	Insignficant *Risk is easily miligated by normal day to day process*	**Minor** *Delays up to 10% of Schedule Additional Cost up to 10% of Budget*	**Moderate** *Delays up to 30% of Schedule Additional cost up to 30% of budget*	**Major** *Delays up to 50% of Schedule Additional cost up to 50% of budget*	**Cata-stroph ic** *Project aban-doned*
Certain *>90% chance*	**Broken sensor**			**Remapping program won't work**	
Likely *50%-90% chance*			**The automatic control system does not want to detect the differ-ence in slope on the road surface with the vehicle**	**ATF won't read the pro-gram**	
Moderate *10%-50% chance*		**The program en-tered is lack-ing/wrong**	**Sensor does not detect tilt acceleration, and orientation**	**Vehicle ECU not reading program**	
Unlikely *3%-10% chance*					
Rare *<3% chance*					

Information:

Green = Less Red = Many

Yellow = Normal

Based on the results of the analysis of possible damage that can occur on the process of compiling the GRADE automatic system using accelerometers and gyroscopes on vehicles in the normal category and has little effect on time and cost namely damage to the accelerometer sensor that does not detect the acceleration and angle of inclination of the vehicle to Earth's gravity will cause the input data entered in the system to be inaccurate even can cause the system to lose input data in the automation process so that the automatic control of the system cannot work optimally. In addition, the possibility of damage or failure of the gyroscope sensor in detecting the orientation of the vehicle will also cause the same thing. Other possible damage that can affect the project planning time and the costs required to compile and assemble the system on the vehicle include: The automatic control system does not want to detect the difference in the slope of the road surface with the vehicle, the program that is inputted on the vehicle is not enough or is wrong until a large enough risk occurs. if the Automatic Transmission Fluid (ATF) system and ECU do not read the program until the remapping program does not work.

The preventive measures and solutions to problems that may arise during project implementation are to carry out periodic testing and analysis on vehicle prototypes that are integrated for some time and ensure the program can run well to minimize the risk of problems or damage that may arise. Another plan that can be done to overcome problems that may arise during project implementation is to do a final check first on the assembly and preparation of the system before installing it on the vehicle either manually or using software assistance. Thus, the final result of the project work achieves the objectives and is in accordance with the expected results.

10. References

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