# A Review on Self Stabilizing Platform in Scope of Merchant Navy Applications


Vinod Kumar S
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
Bengaluru, India
vinosvinothkumar@gmail.com

Mahesh M
*HoD, Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
Bengaluru, India
maheshastu@gmail.com

Vinoth Kumar K
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
*Bengaluru, India*
kvinoth_kumar84@yahoo.in

Amarjeet Singh
*Dean Academics*
*New Horizon College of Engineering*
*Bengaluru, India*
amarjeetsingh.iaf@gmail.com

Mohammed Omer Ali
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
*Bengaluru, India*
mohammedomerali123@gmail.com

Siddhartha Sunil Singh
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
*Bengaluru, India*
siddharthsinghnational@gmail.com

Nayrah M A
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
*Bengaluru, India*
nayrahmaf@gmail.com

Tahoora Imtiyaz
*Department of Electrical and Electronics Engineering*
*New Horizon College of Engineering*
Bengaluru, India
tahooraimtiyaz123@gmail.com

Umair Khan
*Department of Mechanical Engineering*
*Institute of Aeronatical Engineering*
Hyderabad India
64umairkhan@gmail.com



2022 First International Conference on Artificial Intelligence Trends and Pattern Recognition (ICAITPR) | 978-1-6654-2521-6/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICAITPR51569.2022.9844197



***Abstract*—The advancement in robotics in the resent years has led to the integration of multiple disciplines of sciences to research and develop effective and reliable solutions for industries. This model is mainly focused on the Merchant navy industry where we have proposed the implementation if Self Stabilizing platform for various navy applications such as GLB/GLBE cranes, Helipads, etc. This model will be a 6 DoF/6 Axis model which is suitable for the movements for the scope of the applications proposed above. We have tried to fuse two different control methods for this model which are PID controller method and MEMS sensors methods which is a MUP6050 sensor. This model is better than the old mechanical link self-stabilizing platforms which are non-feedback control models. As the ship experiences storms the tilt in the bottom surface is detected and the upper platform tiles accordingly to maintain level and give stability to the GLB crane or the Helipad. This is a dynamic model which has real time active feedback.**



**Keywords—Self Stabilizing Platform, PID controller, MEMS sensors.**


## I. INTRODUCTION

In the recent years the revolution of industry has led to development of machine that tend to replace or cut down human work. This change in the industry has led to the invention of the domain in science known as mechatronics. Mechatronics is branch of applied science which deals with the fusion of electrical and electronics engineering, mechanical engineering & computer science engineering. Mechatronics engineering mostly focus on robotics and key need of today's hour is automation in industries which leads to effective and mass production in industries. Japan for very long time is known for its amazing robotics work and it has been pioneer for very long time. From basic conveyor belts to complex robotics models powered by artificial neural network, this subject has diversified into a lot of branches. [1]

As industry 4.0 has led to complete automation of many robotic machine artificial intelligence has played a major role in automating the process and making the system more productive and efficient for the mass production of the machines, by minimizing the risk of human error and maximize their safety. The leading companies in this field such as ABB, Mitsubishi and Siemens are currently working on the making their system more effective using neural network function is shown in figure.1. [2] In this paper considered the implementation of Stewart's self-stabilizing platform with gyroscopic sensor for stabilizing of the GLB crane in bulk carrier ships. This model focuses on the research and development in self balancing robotics. This self-stabilizing platform will not only be beneficial for above mentioned merchant navy applications, but can also be used in modern robotic models which have real time feedback. [3-4]

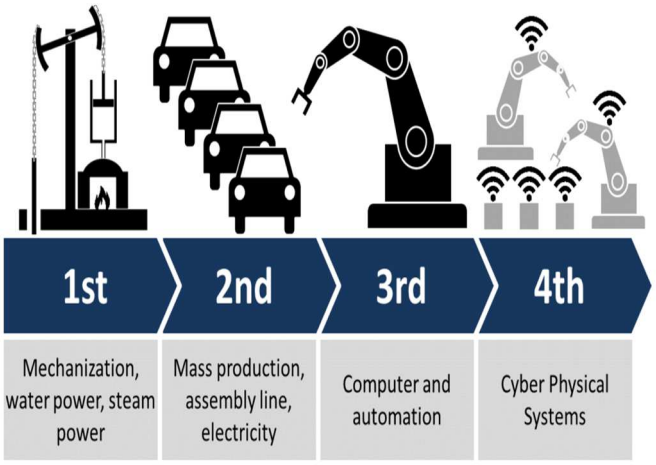


Fig. 1. Block Diagram of Industrial Revolution

The need of self-stabilizing platform in GLB cranes/ service cranes is because they have operational limitations when the bulk carrier/ship is not anchored. The stability issues with this proposed application will be minimized up to an extent. The model proposed here will consist of linear/pneumatic hydraulics according to the load ratings of the crane. This paper will now be divided into two different

parts i.e., working principle and proposed application. The working principle will first address the working technology and then the proposed methodology. Then the application part will consist of two sub parts i.e., proposed application and numerous possible applications is shown in figure.2. [5-10]

Fig. 2. Industrial Automation

## II. Methodology

Stewart's Platform is a kind of self-balancing model which is made of servo/electric motors attached to arms to control the slope and a ball at the upper surface to represent the free roll on that surface. The system proposed here is an example of Closed loop feedback system which specifically represents the Fractional-order PID controller. The PID control system is abbreviation for Proportional-Integral-Derivative controller. This control system is widely used in industry for applications that require continuously modulated control. The function of this control system is to continuously calculate an error value. This value is the difference between desired set point and the measured output of the variable given. This control system then applies a correction continuously which is based on PID terms. [11-12]

The concept of 6 DoF (Degree of Freedom) can be best used to describe the movement of the platform in which we make use of only 3 DoFs i.e., Pitch, roll & yaw the other 3 DoFs are out of scope for the proposed application. The input of this model will initially be the PID control loop once it attains a value which will be close to zero error that will be considered as initial reference value for calibration and then will switch to the input from the gyroscopic sensor. [13]The gyroscopic sensor will further send the input values to the Atmega-328 board which will be calibrated by the reference value set by using the mathematical equation given by

$$T = \frac{1}{2} m (\dot{x}^2 + \dot{y}^2) + \frac{1}{2} J \left(\dot{\omega_x}^2 + \dot{\omega_y}^2\right)$$
$$= \frac{1}{2}\left(m + \frac{1}{r_b^2}\right)(\dot{x}^2 + \dot{y}^2) \quad (1)$$

This equation can be derived from the coordinate axes is shown in figure.3 and The figure.3 gives the calibrated value from Atmega 328 board to the servo motor and in return adjusts the above given platform at 0 degrees. [14] The potential energy stored in the system while the single phase shift is given by

$$V = mgh = mg\left(x \sin\theta_x + y \sin\theta_y\right) \quad (2)$$

Further the two component sin and cosine are expanded to get total potential energy stored at each phase shift. [15-20]

$$\begin{cases} \left(m + \frac{1}{r_b^2}\right)\ddot{x} + mg \sin\theta_x = 0 \\ \left(m + \frac{1}{r_b^2}\right)\ddot{y} + mg \sin\theta_y = 0 \end{cases} \quad (3)$$

The energy stored inside each shift will help us determine the load capacity of the crane to carry the load.

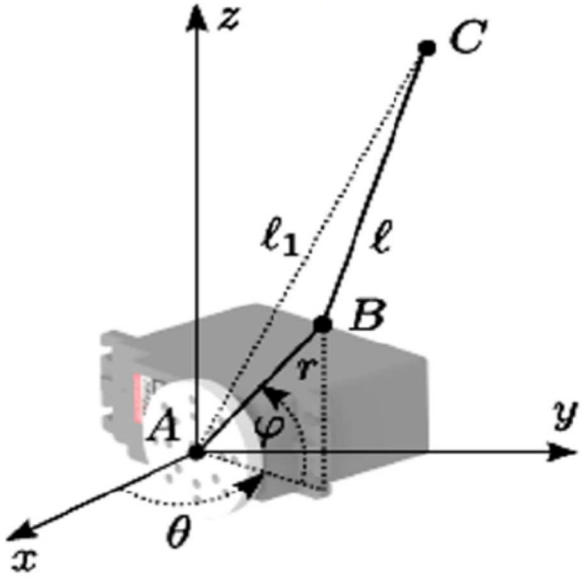


Fig. 3. Coordinate Axes of shaft rotation

Fig. 4. Self-Stabilizing Platform model with 6 DoF

The basic concept of filters is to reduce the noise is any circuit is shown in figure.4. There are basically two types of filters generally used for more accurate output signals i.e., Low pass filter and High pass filter. In this model we have proposed the use of filters for reduction of noise and distortion form the signals received from gyroscopic and accelerometer sensors. In the scope of this paper we have proposed two types of filters named as Kalman filter algorithm and Complementary Filter algorithm.

Kalman filter was proposed by Rudolf E. Kalman is the scope for development in control systems. The basic working of this filter is to take observations of unknown values during

the run and take an analytical result from the unknown values rather than just taking only one value. This digital filter is sometimes termed as Stratonovich-Kalman-Bucy filter because it was implemented by the Soviet Mathematician Russian Stratonovich. [21]

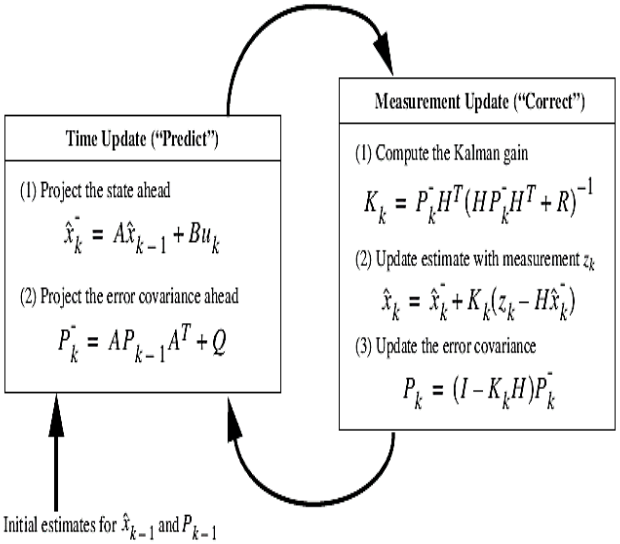


Fig. 5. Covariance matrix for Kalman Filter

The figure 5 represents the error updating by Kalman algorithm in terms of Matrices. This filter algorithm is the easiest algorithm to fuse the data received from Gyro sensor and Accelerometer sensor. This consists of low-pass filter that is common and a high pass filter for gyroscope. The output of this filter will give us more accurate data from which we can determine pitch, roll, and yaw altitude outputs of the upper platform. An example for complementary filter is given in figure 6. [22-25]

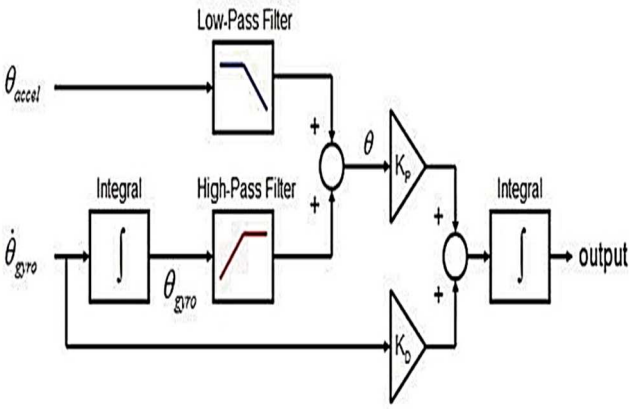


Fig. 6. Complementary Filter

## III. Proposed Applications

The self-stabilizing model proposed above is the principle for which the proposed application will be based on. The limitations identified with the GLB/GLBE cranes is that they cannot be operated while the ship is at its cruising speed and also cannot be operated when there are moderate tides in the ocean. The only difference between the above servo motor model and the application for crane proposed here is that the model will be implemented with linear / pneumatic hydraulic actuator and hydraulics. Once the implementation of the platform will be employed, the cranes will be able to operate even during non-standard conditions up to a certain extent is shown in figure.7.

Fig. 7. 50ft GLB crane on Bulk carrier

One of the other applications of steward's self-stabilizing model is flight simulator is shown in figure.8. Flight simulator uses 6 DoF in order to attain the desired output which is computed by the user who is operating the flight simulator to create real time virtual environment for the user. [26-29]

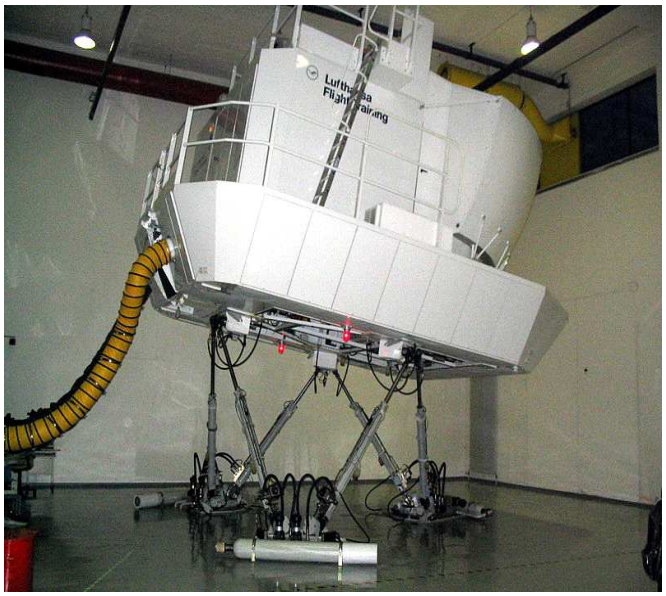

Fig. 8. Simulator model using self-stabilizing Platform

## IV. Conclusions

By the end of this review have witnessed the adverse capabilities of self-stabilizing platform in regards with various applications in various industries. The above working methodology also represents various control methods for a single application and also the integration of two different control methods to improve the response accuracy of the model and add the further capabilities of this model by integration of Artificial neural networks & Fuzzy logic rather than the implementation of PID controllers as it has its own drawbacks as discussed in the above sections. Then the capabilities of integration of modern technologies in existing systems are also a very effective way for automation in industries.

## References

[1] Z. J. Geng and L. S. Haynes, "Six degree-of-freedom active vibration control using the Stewart platforms, Control Systems Technology," IEEE Transactions on Control Systems Technology, vol. 2, pp. 45-53, March 1994.

[2] S. Keshtkar, E. Hernandez, A. Oropez. and A. Poznyakac, “Orientation of radio-telescope secondary mirror via adaptive sliding mode control,” Neurocomputing, vol. 233, no. 12, pp. 43-51, April 2017.

[3] B. N. Agrawal and J. Chen, “Algorithms for active vibration isolation on spacecraft using a Stewart platform,” Smart Materials and Structures, vol, 13, p. 873, June 2004.

[4] P. Han, T. Wang, and D. Wang, “Modeling and control of a Stewart platform based six axis hybrid vibration isolation system,” Proc. of 7th World Congress on Intelligent Control and Automation, IEEE, pp. 25-27, June 2008.

[5] Z. Wang, Y. Sun, G. Qi, and B. J. van Wyk, “Model free control based on GIMC structure,” International Journal of Control, Automation, and Systems, vol. 10, no. 1, pp. 173-179, February 2012.

[6] G. K. I. Mann and B. W. Surgenor, “Model-free intelligent control of a 6-DOF Stewart-Gough based parallel manipulator,” Proceedings of the International Conference on Control Applications, pp. 495- 500, December 2002.

[7] Z. H. Rahman, J. T. Spanos, and R. A. Laskin, “Multi axis vibration isolation, suppression, and steering system for space observational applications,” Astronomical Telescopes & Instrumentation International Society for Optics and Photonics, pp. 73-81, March 1998.

[8] Rajendra Beedu, Ankit, Mohmed Asif Shaik, Sushant Jain “Design, fabrication and performance analysis of solar power bicycle” International Journal of Renewable Energy and Environmental Engineering ISSN 2348 - 0157, Vol. 02, No. 03, July 2014

[9] Wu, H., Pickert, V., Lambert, S., Allanf, P., Deng, X., and Zhan, H., 'A Ripple Reduction Method for a Two Stages Battery Charger with MultiWinding Transformer Using Notch Filter', in, Power Electronics and Drive Systems (PEDS), 2017 IEEE 12th International Conference on, (IEEE, 2017)

[10] Meenal, Prawin Angel Michael., “Weather Forecasting for Renewable Energy System: A Review”. Archives of Computational Methods in Engineering, Springer, pp.no.1-25, January 2022.

[11] Nazi, H., Babaei, E., and Sabahi, M., 'Bidirectional Active Charge Equaliser for Series-Connected Cells', IET Power Electronics, 2019, 12, (5), pp. 1229-1240.

[12] 10. Vinoth Kumar K, Sumaiya Akhtar Mitu, Md. Aslam Mollah, Shailesh Mishra, Kawsar Ahmed., “A Novel Sensitive Photonic Crystal Fiber based Voltage Sensor Filled with Nematic Liquid Crystal”. IEEE Transactions on Nanotechnology (Early Access), pp.no.1-25, 2022.

[13] Vinoth Kumar.K, “Implementation of smart electric vehicle charging station driven using experimental investigation” in the IEEE Xplorer Proceedings of the 2nd Global Conference for Advancement in Technology (GCAT 2021) held at Nagarjuna College of Engineering and Technology, Bengaluru during 1-3, October 2021.

[14] Vinoth Kumar. K, “Execution of smart electric vehicle charging station driven by RE technology using soft computing approach” in the IEEE Xplorer Proceedings of the 2021 Innovations in Power and Advanced Computing Technologies (i-PACT) held at Vellore Institute of Technology, Vellore during 27-29, November 2021.

[15] OmarAli, “A Review on Triboelectric Nanogenerators (TENGs) using Internet of Things” in the IEEE Xplorer Proceedings of the 2021 International Conference on Forensics, Analytics, Big Data, Security (FABS) held at BMS Institute of Technology and Management, Bengaluru during 21-22, December 2021.

[16] D. Rajesh Babu, V. Srikanthbabu, T. Satyanarayana “Solar Tracker Robot Using Dual Tone Multiple Frequency (DTMF) and Microcontroller”, International Conference on Electrical, Electronics, Signals, Communication and Optimization (EESCO2015), Vignan’s Institute of Information Technology, Visakhapatnam, 24th – 25th January, 2015, IEEE International journal 10.1109/EESCO.2015.7253772.

[17] M. Mahesh, Gunapriya B, R.Saravanakumar, S. Gowdham Kumar, “Execution of battery charging for electric vehicles using five level methods”, IEEE Xplorer Proceedings of the 7th International Conference on Electrical Energy Systems, ICEES 2021, 2021, pp.16-21.

[18] Mahesh M, Mesfin Abebe, L. Udayakumar, M. Mathankumar, “A review on enabling technologies for high power density power electronic applications”, Materials Today: Proceedings, 2021, 45, p.81.

[19] Prabhakaran Narayanan, Sudhakar Sengan, Balasubramaniam Pudhupalayam Marimuthu, Ranjith Kumar Paulra, “Novel Collision Detection and Avoidance System for Midvehicle Using Offset-Based Curvilinear Motion”, Wireless Personal Communications, 2021, 119, p.89.

[20] Srinivasa, G., Sujitha, “Spanning trees of a triangle snake graph by BFS and DFS algorithms”, International Journal of Innovative Technology and Exploring Engineering, 2019, 8(8), p.67.

[21] Vinoth Kumar. K, “Experimental Setup of Smart E-Vehicle Charging Station using IOT Technology” in the IEEE Xplorer Proceedings of the 2021 IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC) held at Sri Siddhartha Institute of Technology, Tumkur during 3-4, December 2021.

[22] Vinoth Kumar.K, “Execution of smart electric vehicle charging station driven by RE technology” in the IEEE Xplorer Proceedings of the 2021 IEEE Mysore Sub Section International Conference (MysuruCon) held at Navkis College of Engineering, Hasan during 24-25, October 2021.

[23] Vel Murugan Gomathy, T. V. Paramasivam Sundararajan, C. Sengodan Boopathi, Pandiyan Venkatesh Kumar, Krishnamoorthy Vinoth Kumar, Abhay Vidyarthi, Rajagopal Maheswar, “A 2 × 20 Gbps hybrid MDM-OFDM–based high-altitude platform-to-satellite FSO transmission system”, Journal of Optical Communications, 2020, 34(2), p.56.

[24] S.Boobalan, Venkatesh Kumar P, G.Palai, “Three Ways Chip to Chip Communication via a Single Photonic Structure: A Future Paragon of 3D Photonics to Optical VLSI”, IETE Journal of Research, 2021, 25(1),p.561.

[25] Singaravelan.A, Kowsalya M, J.Prasanth Ram, Gunapriya B, Young-Jin Kim, “Application of Two-Phase Simplex Method (TPSM) for an Efficient Home Energy Management System to Reduce Peak Demand and Consumer Consumption Cost”, IEEE Access, 2021, 9, p.651.

[26] Adhikary P, Roy P. K., Mazumdar A, “Optimal Renewable Energy Project Selection: A Multi-Criteria Optimization Technique Approach”, Global Journal of Pure and Applied Mathematics, vol.11., no.5, pp.no. 3319-3329, 2015.

[27] T. Logeswaran, S. Karunakaran. “The generalized non-linear fresnel transform and its application to image encryption”, Elsevier, Materials Today: Proceedings, vol.45, no.5, pp.no.132-142, Dec. 2020.

[28] Pradip, Lydia M. “A Comprehensive Overview on PV based Hybrid Energy Systems”, International Journal of Renewable Energy Research, September 2019; 9(3), pp. 1241-1248.

[29] M. Ramkumar, Vijay Ananad. “ECG Cardiac arrhythmias Classification using DWT, ICA and MLP Neural Networks”, Journal of Physics Conference Series,vol.1831, pp. 1-13, Mar. 2021.