**Research Question: How do I design a device or system that can continuously measure a ship’s draft height during various sea conditions?**

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| **Source** | **Draft Line Detection Based on Image Processing for Ship Draft Survey** | **Real-Time Water Level Visualization with Pervasive IC Sensors** | **Naval architecture and system engineering: A deal for naval ship design evolution** | **Trim and draft control capability of the variable buoyancy ship** | **Highly accurate noncontact water level monitoring using continuous-wave Doppler radar** |
| **Citation** | Ran, Xian et al.,2012 | Osamu, Saitou et al.,2013 | Gualeni, P. Dazzi, N., 2009 | Parsons, M. Kotinis, M.,2011 | Wang, Guochao et al.,2013 |
| **Purpose** | * To access a new method for measuring a ship’s draft survey that will be more accurate and safe then manual observation.
* The measurement of a ship’s draft height will be done using computer image processing software coupled with mathematical algorithms which if completed correctly will display the correct height
 | * A computer monitoring water level indication system has been created to aid with early warning of flooding in smaller towns with heavy rainfall.
 | * Provide a brief background to naval architecture and systems engineering including its origin and it complexity in design requirements.
* Discussion of naval architecture’s evolution throughout the centuries to its current state.
* Demonstrate the implementation of science into ship design and testing.
 | * Introduction of a new method for controlling list, buoyancy, and draft a conventional cargo ship involving variable tanks which can be emptied and filled simultaneously ensuring safe sea operations.
* The article reviews the benefits of a ballast free ship with trunks running along the waterline.
 | * The accurate monitoring of water levels from rainfall.
* The purpose of this article is to study the changes on water level from a slow varying container of water.
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| **Why is the study necessary?** | * Provides a safer way to measuring ship draft height.
* Draft is important to predict cargo load capabilities during any sea conditions.
* Measuring draft aids navigators in choosing best fit route for sea transit.
 | * Early detection of flooding may be vital to a town’s or countries survival.
* Water level monitoring can be useful not only for flood monitoring but also to help detect draught.
* Early detection of major storms can ensure proper preparation and possible prevention.
 | * This study is necessary since it helps engineers understand the challenges of the past.
* By understanding the past, engineers and scientists can suggest the best path for the future.
 | * This study is necessary since draft, list, and buoyancy are all important factors for safe sea travel whether the vessel is carrying cargo or not.
* The variation on sea density, fuel usage, and possible cargo all require a simple method for adjusting the ship conditions.
 | * Accurate water level monitoring is key to accessing various conditions such as rainfall accumulation, and can be even be spread to study flooding and precipitation rate.
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| **Methods** | * Computer based image processing systems
* Images are collected from the 6 measurement points and color detection couples with algorithms filter out wave lines to display draft line.
 | * The computer based monitoring system uses water level sensors installed into pipes laid out across the land a vulnerable locations.
* These sensors use short wave radio signals to communicate with one another in detecting water level changes and pressure changes.
* The sensors aid in mapping a storms direction and the affected areas after a storm.
 | * Discussion of naval architecture covers the being from before the scientific period in the 1600s and progresses to the 21st century.
* The article discussed Newton’s law of physics, Einstein’s theory of relativity and Plank’s quantum theory in relation to ship design.
 | * Trunks line along the waterline serve as the means for controlling the ballast, list, and draft of the vessel.
* The vessel is equipped with 6 trunks separated by isolation valves in the event of ship flooding.
* The valves allow full and partial loading to correct for external cargo.
 | * The system use radar pulse technology to accurately monitor water levels with on directly being in contact with the water.
* The radar sends continued pulse signals to the surface of the water which then travels back to the radar device accurately measuring the distance travelled.
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| **Results** | * The experiment demonstrated the method is effective yet complicated due to mathematics and tedious process.
* The 3 color image filters create room for error if used incorrectly.
 | * Although no major storm or flooding has occurred since the systems implementation, the system has been successful in monitoring precipitation changes with the test area which can aid in the early detection of storms.
 | * The article provided a detailed outline of the history, evolution, and challenges involved in naval architecture.
* The changes in science and history has affected the stages for ship design and naval thinking.
* Developments in science create a method for hypothesizing and testing such designs.
 | * The resulting system is one that can be emptied or fill simultaneously ensuring maximum control of ship behavior.
* The tanks or trunks may act as one unit or separated through valves allow for precision loading and adjustments.
 | * The radar device has been tested and has accurately demonstrated it accuracy in measuring water level distance to a high degree of accuracy.
* The device has been accurate in the presence of water ripples but has displayed increase error when the water level is high due to signal disturbances.
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| **Discussion/Conclusion** | * The draft line is taken from its position in relation to the waterline. Yet the waterline complicates the reading if one cannot distinguish between the two.
* Draft survey measurement can be successfully completely using image processing if the exact steps are followed which are outlined in this article.
 | * A complete water level monitoring system has been tested and deemed valuable in early detection of flooding or storms.
* The system has been adopted in other areas of Japan to aid in prevention and early detection of earthquake storms.
 | * The history of naval architecture is discuss to provide insight to it evolution and quickly changing nature.
* The design process has become complex and automated in nature.
* This change requires engineers to understand innovative tools and techniques such as automated tools used for designing naval vessels.
 | * The system is adequate for controlling ship trim and draft conditions but will still need an external monitoring system to aid navigators with visualizing current conditions.
* Visualization of the system is achieved using a vessel polygon displaying ship changes in various conditions.
 | * The monitoring system has been more accurate in tranquil waters.
* The device has also been less accurate in fasting changing water levels.
* The technology is beneficial in tank level monitoring, as well as rainfall monitoring.
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| **How can this help my senior project?** | * This article provides a method of measuring draft survey which can be valuable for reference information.
* Equations and sea characteristics can be reused when our team evaluates our design.
* The method can also be studied for improvements or adjustment which could make our design better.
 | * Water level sensors can be a useful implementation to the Fleet if the sensors can be successfully mounted onto a vessel.
* This technology can provide and integrated method for monitoring a ship’s draft height.
* The article provides a load of information including, types of sensors, and effective layout which can be help with project design.
 | * Understanding the methods for naval ship design will be helpful in designing a draft measurement device.
* Naval architecture provided insight to where our device will be possible and more suitable.
* This article may also lay some light onto possible complications.
 | * This article provided information in regards to ship behavior with ballast tanks or the new variable buoyant trunks.
* This information can be used to access how a draft monitoring system may be implements into the ship.
* The article also brings up some challenges that may lie ahead such as the implementation of list monitoring.
 | * This technology was on first idea for the ship draft project.
* The technology is suitable for systems in which accurate and continuous water level monitoring is required.
* The portability of the technology may be beneficial our project design.
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Works Cited

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