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Education

1. ***Doctor of Philosophy***: Indian Institute of Technology Madras, Chennai. July 2016
   Thesis title: Hydrodynamic optimization of underwater vehicles using genetic algorithm integrated with CFD.
2. ***Dual Degree*** (***B. Tech and M. Tech***): Saint-Petersburg State Marine Technical University, Russia
   Sept ' 2004 - Feb ' 2010
   Major: Naval Architecture and Ship Building and Minor: Ship Production and Manufacturing with a CGPA of 5/5.

Professional Experience (Teaching)

Asst Professor Grade – I at Department of Ocean Engineering and Naval Architecture, IIT-Kharagpur, Kharagpur, West Bengal, India. November 2023 – Current

a. Teaching:

Under-graduate courseworks: Maneuvering and control, Linesplan lab, Hydrostatics lab
Position of responsibility:
Faculty advisor for UG Batch 2023-27
Assistant warden MS Hall, IIT Kharagpur

Asst Professor (SG) at Department of Mechanical Engineering, Amrita School of Engineering, Amrita Viswa Vidyapeetham, Chennai, India. June 2019 – November 2023

a. Teaching:

1. Under-graduate courseworks: Engineering Graphics, Fluid Mechanics, Computational Engineering Mechanics, Instrumentation and Control systems, Automation and IoT, Programming in C
2. Position of responsibility:
   - Campus NBA coordinator
   - Involved in establishing all B.Tech laboratories
   - Robotics club faculty in-charge,
   - Faculty in-charge for Robotics and Automation lab, 3-D printing lab.

Asst Professor at Department of Mechanical Engineering, Hindustan University, Chennai, India. Feb 2015 – April 2019.

a. Teaching:

1. Under graduate subjects: Engineering Mechanics, Mechatronics, Engineering Graphics, Fluid Dynamics
2. Post graduate subjects: Optimization techniques in engineering design, Advanced Strength of Materials and Advanced Fluid Mechanics
3. Position of responsibility:
   a. Campus NAAC and NBA coordinator
   b. Faculty in-charge for Computer Aided Engineering Lab
   c. Class Advisor

I have developed a teaching philosophy which emphasizes collaborative learning; my goal is to teach my students valuable communication skills as well as the ability to think critically about modeling real world problems. To me, being an educator means having many roles: teacher, researcher, mentor. Being an excellent teacher is one of my primary goals, and I feel that my experiences will make me an extremely effective teacher in university environment. I will also

contribute to my future department, in everything from service activities to mentoring for students and other faculty. As a faculty member, I hope to be involved in designing course materials for the theory curriculum. My goal in teaching is to show my students, how I am excited about the material, in my experience, this excitement does more to get them past the technical difficulties than anything else. I strive to be approachable and fair, so that students feel free to ask questions and come visit office hours to talk about problems. I am constantly striving to identify and address the weaknesses in my teaching.

My research and teaching focus is optimization techniques in Engineering Design, Computational Fluid Dynamics and Robotics. The topics provide an elegant mathematical way to approach real world problems, but they are challenging to teach. There is no list of items to memorize; rather, students must learn how to formally model problems and how to effectively and clearly give solutions to those problems. This type of critical thinking is the most essential tool for problem solving in engineering design, and it is also one of the most engaging to teach. Expressing algorithms and proofs in a coherent manner is a learned skill, and my primary goal is to help my students develop the tools necessary for this skill. My teaching methods and philosophy have developed through my experience as a student. I understand that collaborative learning is the key element of education. I would like to teach undergraduate courses like Strength of Materials and Robotics, as well as modeling and introductory programming courses. I hope to use these courses to find strong undergraduates whom I can incorporate into my research group. I would also be very interested in teaching advanced topics courses in computational fluid dynamics, optimization techniques and marine hydrodynamics.

Professional Experience (Research)

Design of Underwater Vehicles

The demand for natural resources, necessity to understand Earth's weather patterns, protection of coast from adverse attacks and national defence have motivated the research for exploration of the oceans. The exploration of ocean space requires underwater vehicles (UV) such as submarines, autonomous underwater vehicles (AUV), manned underwater vehicles, remotely operated vehicles (ROV) and ship towed instrumentation packages. Of these, AUVs dominate the exploration of deep oceans and these AUVs are torpedo shaped in general. This is mainly because of the compromise the naval architects and engineers make between many design constraints like volume required, delivered power, drag, hydrodynamic stability etc. of the vehicle. These torpedo-shaped vehicles are good in terms of reduction in drag, but it is very difficult for them to hover at a particular location. In this project, an AUV with fins and propeller will be designed through an optimisation framework which will be developed in OpenFOAM considering all the design parameters and a Model Predictive controller to control the AUV. An AUV model with AC servo controlled actuator affixed will be fabricated to verify the simulation results. The experiments will be conducted on both cruciform and X-form fins. The design of UV is mission specific and each UV is unique in design because it needs to cater to its unique set of mission requirements. However, the design objectives related to their underwater usage are based on hydrodynamic drag, power, propulsion, manoeuvring and buoyancy control. Of these, the hydrodynamic drag is most important because it directly affects the power requirement, range, and endurance. Therefore, minimization of drag is the central objective in AUV design and it is an important problem in the area of marine hydrodynamics. This can be accomplished, in general, by some combination of (i) streamlined shaping of the hull, (ii) controlling boundary-layer, e.g., polymer injection or slot suction, (iii) energy-saving propulsion; e.g., a wake adapted propeller or a suction slot with a stern jet, and (iv) efficient maneuvering consistent with hydrodynamic stability. The first two of

this list attempt to reduce skin friction and pressure drag while the third attempts to extract energy lost to the fluid surrounding the vehicle. A complete systems design must simultaneously take into account all these four aspects though the complex nature of the complete problem does not permit analytical systems design approach (Vasudev et al., 2014, Parsons et al., 1974). This research is published in Methods in Oceanography.

Design of underwater vehicles with minimization of delivered power as main objective

The design of Underwater vehicles (UVs) requires reliable and accurate estimation of hydrodynamic forces that act on them so that the complex demands of range, endurance, payload, operational flexibility, navigational capabilities in deep and restricted areas of operation and energy efficiency can be assessed. Some of these requirements can be conflicting in nature and therefore, the design requires that an appropriate compromise between them be made. The traditional approach adopted in hydrodynamic design is to take recourse to experimental evaluation of the forces such as drag, lift, added inertia and hydrodynamic damping, effective power, wake fraction, thrust deduction, propeller thrust and torque, etc. This approach is increasingly being supplemented by computational fluid dynamics (CFD) approach so that dependence on experiments, which is both time consuming and costly, becomes minimal. In other words, the GA code, the CFD mesh generation code and the CFD solver are integrated so that the entire exercise can be carried out without any intermediate user interruption or intervention during the entire optimisation process (Vasudev et al., 2017).

Designs of a submarine with two objectives drag minimization and volume maximization

A NSGA-II-based multi-objective (drag and volume) optimization model integrated with CFD for shape design of submarine hull described by a simple 5-parameter formula. The shape of the sail is assumed fixed and hence is not a part of the optimization process but its longitudinal location over the submarine hull is an outcome of optimization. Two approaches to optimization are explored, one optimizes the combined ‘‘hull shape–sail location’’ and the other optimizes the hull shape first, and for this optimized hull shape, the sail location is optimized next. The former approach yields lower drag and negligibly small hull–sail interaction so that one has wider latitude to place the sail anywhere over the length of the submarine. This approach was chosen to obtain an optimum design considering the range of operating speed of the submarine. The GA and RANS solver are seamlessly integrated in a single code so that it becomes an effective computational tool for optimization. This approach can be extended to multi-objective problems that include wake fraction of the hull which is an important design parameter. This work is published in JEME (Vasudev et al., 2017).

Genetic algorithm optimization based nonlinear ship maneuvering control

A Target Path Iteration (TPI) algorithm integrated with genetic algorithm for course keeping of cargo ships has been proposed. The algorithm allows direct time domain simulation of the nonlinear differential equations of maneuvering based on the partial solution of the inverse problem of ship maneuvering. The performance of the present algorithm in comparison with previously proposed TPI algorithm has been extensively assessed for straight line and curved trajectories. The results show that the present algorithm outperforms the TPI algorithm in critical cases. This study has, how-ever, neglected the environmental disturbances on the ship which are inevitable. A possible extension of the present work may be an inclusion of the wind, waves and current disturbances on the ship.

Authentication key generation for internet of drones

There exist a lot of authenticated key agreement protocols for the security of transmitted data through drones. We have analyzed a recent authentication and key agreement protocol by Zhang et al. in year 2020. We have found that this protocol is not secure against stolen smart card attack, and the control server stores extra data. Therefore, We have tried to address security issues of password guessing, anonymity, user/server impersonation, insider attack, and stolen smart card attack, and man in the middle attack. We have proposed a modified lightweight authenticated key agreement protocol for Internet of Drones. The proposed protocol is proved secure in the random oracle model. A performance analysis of proposed protocol with relevant protocols ensures its efficiency, and security as well. This protocol useful for internet of drones, e-healthcare, and internet of unmanned vehicles. This work is published Internet of Things Elsevier.

Prediction of Calophyllum inophyllum biodiesel through two-stage transesterification

Artificial Neural Networks (ANN) are used in optimizing the process variables for the transesterification process of C.inophyllum oil. The variable parameters namely, methanol to oil molar ratio, catalyst concentration and reaction duration to maximize the biodiesel yield are considered. The results proven to be very promising. This work is published in Energy Sources, Part A: Recovery, Utilization, and Environmental Effects.

My research focuses on developing optimization framework for the design of AUVs/AUGs integrated with Computer Aided Geometric Design (CAGD), Computational Fluid Dynamics (CFD) and Genetic Algorithms (GA). This framework will assist the engineer/designer in taking engineering decision in the process of design of AUVs/AUGs. The modular framework is very convenient in implementing modules even separately depending on the stage of design, available computational resources, objectives etc. The main advantage of this framework is its ability to identify the optimum hull forms in terms of the objectives selected by satisfying the constraints applied. I have a strong background in geometric and topological techniques, algorithm design and analysis, and modeling and simulation. These combinations allow me to consider design, modeling and analysis from a unified perspective and develop novel and efficient computational methods for them. I believe that understanding the mathematical models of vehicles enables one to solve it in a systematic as opposed to an ‘ad-hoc’ way. The long term goal of my research is to continue my pursuit of discovering and devising efficient algorithms for vehicles of real world, and studying both their theoretical and practical issues.

Publications

I have been publishing papers in leading journals with my research students and collaborators

Journal publications

- V Hariram, KL Vasudev, A Sivasankar, D Leela Charan, M Sujit, Rishabh Verma, SRK Lindsay, P Naseem Hussain, B Hari Sankar Ram, DG Adarsh, Patan Irfan Khan (2023) Automotive Wheel Rim using Carbon Reinforced Composite Material–Finite Element Analysis & Investigation, International Journal of Vehicle Structures & Systems, 15(4), 519-523.
- KL Vasudev, V Hariram, B Gajalakshmi, R Christu Paul, G Sai Prajith, M Vinoth Kumar, M Balachandar, E Sangeethkumar (2023) Fluid Flow and Heat Transfer Studies around Impermeable and Porous Cylinders at Low Reynolds Number using Computational Fluid Dynamics, International Journal of Vehicle Structures & Systems (IJVSS), 15(4)

- V Hariram, KL Vasudev, A John Presinkumar, A Sajitha Banu, A Saravanan, M Vinothkumar, P Sarmajikumar, J Godwin John (2023) , International Journal of Vehicle Structures & Systems (IJVSS), 15(4).
- Dharminder Chaudhary, Tanmay Soni, **Kondeti Lakshmi Vasudev**, Kashif Saleem (2023) A modified lightweight authenticated key agreement protocol for Internet of Drones, Internet of Things, Vol. 21. DoI: https://doi.org/10.1016/j.iot.2022.100669
- V Hariram, **KL Vasudev**, A Sivasankar, DL Charan, M Sujit, Rishabhverma, SRK Lindsay, PN Hussain, B. Harisankarram, DG Adarsh, PI Khan (2023) Automotive Wheel Rim using CRF composite material - An FEA investigation, IJVSS, Vol. 15(3). DoI: 10.4273/ijvss.15.03.05
- Hariram, V.; Saravanan, A.; Nadanakumar, V.; Vinoth Kumar, M.; Balachandar, M.; John, J. Godwin; Seralathan, S.; **Vasudev, K. L.** (2022) Optimized Grapeseed Biodiesel Productionand its Effect on the CI engines Combustion Characteristics at Variable Compression Ratios. IJVSS, Vol. 14(2), pp.242-256. DoI: 10.4273/ijvss.14.2.19
- Hariram venkatesan, Godwin John Johnrose, Saravanan Arumugam, Vinoth kumar mari, Balachandar moorthy, Johnson samuel stalin, and **Kondeti lakshmi vasudev** (2022) optimized biodiesel production from c. inophyllum bio-oil using kriging and ann predictive models . thermal science journal vol. 26(5b), pp 4217-4232 doi: https://doi.org/10.2298/tsci211127032v
- Venkatesan Hariram, Dhanush C, Ezhil Maran K, Akilandabharathi K, Md.Faizaan A, Sivamani Seralathan, **Vasudev K. L.** & T. Micha Premkumar (2021) Performance assessment of artificial neural network on the prediction of Calophyllum inophyllum biodiesel through two-stage transesterification, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, vol 43(9) pp.1060-1072 Doi: https://doi.org/10.1080/15567036.2019.1634164
- DK Gupta, **KL Vasudev**, SK Bhattacharyya (2018) Genetic algorithm optimization based nonlinear ship maneuvering control, Applied Ocean Research, Vol. 74, pp. 142-153. DoI: https://doi.org/10.1016/j.apor.2018.03.001
- **Vasudev, K. L.**, R. Sharma and S. K. Bhattacharyya (2017) Shape optimization of an AUV with ducted propeller using GA integrated with CFD. Taylor and Francis, Ships and Offshore Structures. DOI: 10.1080/17445302.2017.1351292
- **Vasudev, K. L.**, R. Sharma and S. K. Bhattacharyya (2017) "Multi-objective shape optimization of submarine hull using genetic algorithm integrated with CFD". Proc IMechE Part M: J Engineering for the Maritime Environment. DOI: 10.1177/1475090217714649
- **Vasudev, K. L.**, R. Sharma and S. K. Bhattacharyya (2016) "A modular and integrated optimization model for UVs". Defense Science Journal, 66(1): 71 - 80.
- **Vasudev K. L.**, R. Sharma and S.K. Bhattacharyya (2014), "A multi-objective optimization design framework integrated with CFD for the design of AUVs using NSGA-II" Journal of Methods in Oceanography, 10: 138-165

Conference proceedings

- Melanthuru Sahil, **KL Vasudev**, Anne Abhiram, Sunkesula Hasan Basha (2023) Design and Fabrication of threat alerting system for continuous monitoring of patients with seizure and heart attack risk using IoT. 2022 IEEE Industrial Electronics and Applications Conference (IEACon) pp 218-222 DoI: 10.1109/IEACon55029.2022.9951826
- S. Seralathan, V. Hariram, M. Sathishkumar, and **K. L. Vasudev** (2023) Comparison of Hydrodynamic Characteristics of Porous and Solid Square Cylinder at Low Reynolds Number Using

CFD, International conference on Energy and Materials Technologies. pp 273-285 DoI: https://doi.org/10.1007/978-981-19-3467-4_17

- Kumar M. W., Vijay S. J., **Vasudev K. L.** and Gnanaraj S. D. (2017) "Reduction of discomfort in pushing an industrial trolley using ergonomics", 14th International conference on science engineering and technology IOP Conf. Series: Materials S and Engineering 263. doi:10.1088/1757-899X/263/6/062042
- **Vasudev K.L.**, R. Sharma and S.K. Bhattacharyya (2015), "An optimization model incorporating clash free mechanism for design of AUVs", In proceedings: UT 2015 IEEE Symposium, NIOT, Chennai, India, ISBN: 9781479982998, DOI:10.1109/UT.2015.7108266.
- Patitapaban Sahoo, **K. L. Vasudev**, R. Sharma and T. Asokan (2015) An optimization design model for VBS for AUVs/AUGs. Journal of engineering, management and pharmaceutical sciences, ISSN: 0976-8416, Vol. 5(1), pp. 1-5.
- **Vasudev K.L.**, R. Sharma and S.K. Bhattacharyya (2014), "A CAGD+CFD integrated optimization model for design of AUVs", In proceedings: IEEE/MTS conference OCEANS 14, Taipei, Taiwan, ISBN: 978-1-4799-3645-8, DOI: 10.1109/OCEANSTAIPEI.2014.6964557.
- **Vasudev K.L.**, R. Sharma and S.K. Bhattacharyya (2014), "An optimization model for design of AUVs", In: Proceedings of the 10thInternational Conference on Advanced Computing Methodologies - India (ICSCI (India)-2014), IEEE, New York, pp. 160-163.
- **Vasudev K.L.**, R. Sharma and S.K. Bhattacharyya (2013),"A multi-criteria decision based robust optimization model for design of AUVs", In: Proceedings of the 7th International Conference on Advanced Computing and Communication Technologies – India (ICACCT (India) - 2013, INDERSCIENCE, UK, ISBN: 9789383083381, pp. 8-14.
- **Vasudev K.L.**, R. Sharma and S.K. Bhattacharyya (2013), "An optimization model for design of AUVs", In: Proceedings of the 2nd International Conference on Advanced Computing Methodologies - India (ICACM (India)-2013), Elsevier, North Holland, ISBN: 9789351071495, pp. 1-7.

Book Chapters

S. Seralathan, V. Hariram, M. Sathishkumar, and **K. L. Vasudev** (2023) Comparison of Hydrodynamic Characteristics of Porous and Solid Square Cylinder at Low Reynolds Number Using CFD, International conference on Energy and Materials Technologies. pp 273-285 DoI: https://doi.org/10.1007/978-981-19-3467-4_17

Chapter: Review of Autonomous Underwater Vehicles in the book title "Autonomous Vehicles" Editor: George Dekoulis, Publisher : InTechOpen, London, UK.
https://www.intechopen.com/books/6864

Awards and Patent

Patent: Application# 202341045077 filed on 5th July 2023, Published on 1st September 2023. System for converting water wave energy to electrical energy

- S. Seralathan, V. Hariram, M. Sathishkumar, and **K. L. Vasudev** (2023) Comparison of Hydrodynamic Characteristics of Porous and Solid Square Cylinder at Low Reynolds Number Using CFD, International conference on Energy and Materials Technologies. pp 273-285 DoI: https://doi.org/10.1007/978-981-19-3467-4_17 **Best paper presentation award from International Conference on Energy and Materials Technology**

- Received young research faculty award from Venus international, Chennai in 2015
- Session chair for AUV/AUG session in IEEE/MTS OCEANS'14 conference in Taipei, Taiwan.

Sponsored Research and Industrial Projects

Sponsored Research Projects

Design and development of an AUV to operate at depths of 100m

Funding agency	University Internal Grants Amrita Viswa Vidyapeetham
Sanctioned amount	10,00,000 INR
PI	KL Vasudev
Duration	2 years
Status	On going

The following are the objectives of this project

1. Develop an optimisation design framework to automate the early stages of design of AUVs within OpenFOAM.
2. Design an AUV with the framework developed within OpenFOAM and further develop a framework to find the hydrodynamic derivatives by conducting numerical experiments within OpenFOAM.
3. Conduct towing tank experiments at Seoul National University, South Korea.
4. Conduct Planar Motion Mechanism tests to find the hydrodynamic derivatives.
5. Develop an algorithm based on Model Predictive Control and implement it using the derivatives obtained in step 4;
6. Conduct numerical and wave tank experiments on few predefined paths and compare the results.

Design and analysis of underwater towed bodies

Funding agency	Naval Physical and Oceanographic Laboratory, DRDO, Kochi
Sanctioned amount	64,00,000 INR
PI	KL Vasudev
Duration	18 months
Status	Approved

The following are the objectives of this project

1. Development of design framework using genetic algorithms integrated with Computational Fluid Dynamics (CFD).
2. Identification of optimum location and dimensions of wings and tow point on the body with minimization of drag and lift as the objective.
3. Studying the hydrodynamic motion performance, namely, Roll, Pitch, Heave, Sway, Yaw of the optimum towed body using CFD.
4. Numerically structural analysis can be carried out on the optimum towed body considering all dynamic loads acting at 200m depth
5. Towing tank tests can be executed with a fabricated model as per Froude scaling and ITTC regulations in the towing tank facility available in the Department of Ocean Engineering, IIT-Madras.

Project Officer at Department of Ocean Engineering, ICSR, IIT-Madras Apr '10 - Dec '14
Modeling and simulation

a. **Project Title:** Hydrodynamic behavior of a floating canopy for client Ship Building Center, Vizag.

- Studied the behavior of rectangular pontoon system in which, pontoons are connected with mooring lines. The variations in response amplitude operators of single pontoon, two pontoons and multiple pontoon system for different frequency waves were reported. The study is carried out using hydrodynamic analysis software Ansys Aqwa.

b. **Project Title:** Seismic Response of 6.6 KV Bus duct Systems, Bhavini, Kalpakkam

- Studied the seismic behavior and postulated failure conditions of bus duct structure under different seismic loading. Reported the failure conditions and additional measures to make sure the structure is safe. The study is carried out using structural analysis software MSC Nastran. Modeling is carried out using MSC Patran.

c. Estimation of hydrodynamic loads on inclined pipes (Morison solution) is implemented and generalized in Matlab.

d. Pile penetration depth under water on the sea bed with different kinds of soil was solved and a small program was developed on the same in Matlab.

e. A small program was developed in Matlab to estimate the shear force , bending moment and deformation of beam with all types of loads acting on it.

f. A small program was developed in Matlab to estimate the amplitude and natural frequency of vibration on a beam with single degree of freedom.

Conferences & workshops organised

1. Specail talk on career guidance in Ocean Engineering and Naval Architecture at Tarunotsav 2024, Venue: Shri PM Kendriya Vidyalaya, IIT Kharagpur.
2. Treasurer and member, core committee 1st International Conference on Advanced materials, manufacturing and Automation (AMMA2023) organised by Department of Mechanical Engg., Amrita School of Engineering, Chennai April 7-8 2023
3. Coordinator, Internship on the Design of Industrial Pneumatic Circuits organised jointly by Department of Mechanical Engineering, Amrita School of Engineering and Festo Didatic India Pvt Ltd. 23-31 Jan 2023
4. Resource person, ATAL FDP on Collaborative Robots and Drones: Controls, AI Techniques and Applications on Industry 4.0, organised jointly by Department of Mechanical Engineering, Amrita School of Engineering and AICTE.
5. Invited Speaker, AI applications in CFD, 5-day FDP on AI and Machine learning applications in Mechanical Engineering, organised by SRM university, Vadapalani Campus, Chennai, 4-8th October 2021.