Optimize solution to reduce vertical link misalignment in Underwater Wireless Optical Communication systems (UWOC)

Introduction:

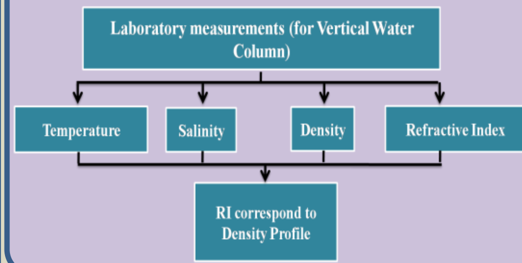
There is a recent shift in the use of optical wireless communications systems like Remotely-operated vehicles (ROVs), Autonomous underwater vehicles (AUVs) and underwater wireless sensor networks (UWSNs) for underwater applications like ocean environmental monitoring, ocean research and underwater exploration. Demand for use of robotics in underwater surveillance in order to increase precision and operability (1). Underwater communication systems are crucial piece in the underwater surveillance and data transmission. In the recent year's underwater wireless optical communication systems (UWOC) with high bandwidth has become a growing research trend. Traditional methods used cabled or fibre-based techniques which provide high speed and reliable communication. Still there are some difficulties in their use at remote locations and Deep Ocean, where the range and maneuverability will be limited. In such scenario, there's a broad interest in the use for wireless optical communication techniques (2).

Research Interest and Proposed work:

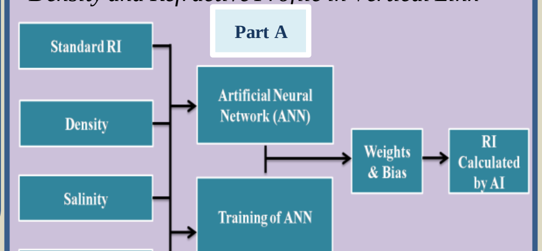
Here, I would like to work in the field of Ocean Optics and to use Visible Light Spectrum as my Ph.D work. As underwater communication is the recent trending topic and in the future, the vertical link is the key factor for the Underwater Communication. Many factors affect light in the ocean, terms of light scattering and attenuation, here, I am proposing difference in the densities in vertical water column can act as different medium for travelling light beam and may affect expected travel path. At this point, we can measure Refractive index of different densities of water column, where we can propose relation between Density and Refractive index (3). Further, I would attempting to develop model using Artificial Intelligence for vertical link misalignment, giving water density as an input to get RI and Beam Divergence.

Approach and Methodology

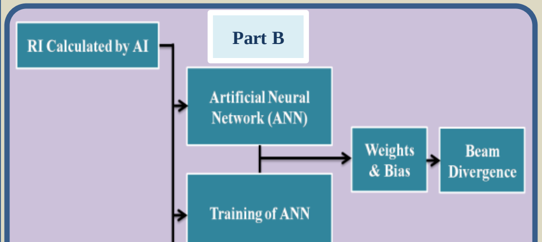
Objective 1: *Optical Water channel modeling* for Density and *Refractive Profile in Vertical Link*



Objective 2- *Optical Water channel modeling for Density and Refractive Profile in Vertical Link*



Part A: Y_1 = Tansig (IW_1* W_d + B_{i1})
RI = $\sum LW_1 * Y_1 + B_{o1}$

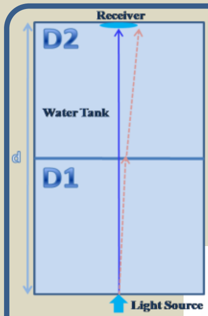


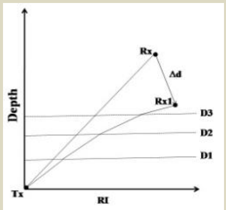
Part B: Y_2 = Tansig (IW_2* RI + B_{i2})
$\theta = \sum LW_2 * Y_2 + Bo_2$

Loss of Light in Ocean, (3,4,5&7) $\quad$ $c(z, \lambda) = a(z, \lambda) + b(z, \lambda)$

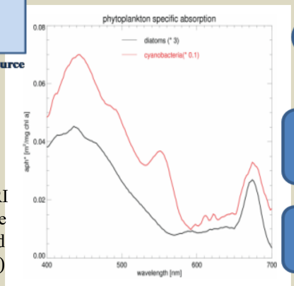
$$a_{TOTAL}(\lambda) = a_w(\lambda) + a_{ph}(\lambda) + a_{NAP}(\lambda) + a_{CDOM}(\lambda),$$

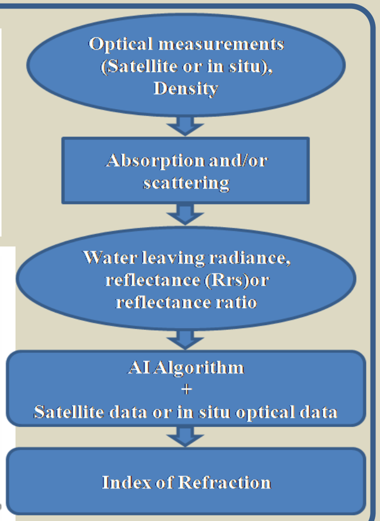
$$b(z, \lambda) = \int_0 \int^{4\pi} \beta(z, \theta', \varphi', \theta, \varphi, \lambda) \sin\theta' \sin\theta \, d\theta' \, d\theta \, d\varphi' \, d\varphi$$





Figure, Tx – Transmitter, Rx & Rx1 Receiver d1-d2 depths, D1-D2 Water Densities, n1-n2 points where RI changes, Δr difference between expected and actual optical path (3)





Expected Outcomes

Objective 1:

1) Refractive index of water body in vertical column with different densities of water will be studied and reported.
2) Study will provide us with the better understanding of modeling in vertical communication links.
3) Relation between different water bodies (different densities) and Refractive Index can be formulate

Objective 2:

1) One can derive transmitter-receiver (Tx/Rx) position by just knowing Water Density profile.
2) The use of ANN in UWOC system will provide cost and energy efficient solution Underwater Wireless Optical Communication Systems.
3) ANN will be used to derive RI, Δd and θ remotely instead of field survey every time, by knowing density profile of water column and to do manual measurements.

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