

Dynamic Underwater Acoustic Sensor Network's Lifetime Improvement

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ABSTRACT: Wireless communication is easy in earth surface, when compared to Underwater Acoustic communication in sea or ocean and this is done by Underwater Acoustic Sensor Network [UASN]. In earth the sensors battery power can be charged manually or through solar power but in UASN it's not easy to do the same. So we can save the battery power which is available in the UASN. We can save it by sleep scheduling scheme by developing a Heuristic Search Algorithm (Multi-population Harmony Search Algorithm). In previous work they took only static type network but in this we designing it for dynamic type (changes by time, either the sensor is active, malfunctioned, dead or lost) network. In this we consider the 3D architecture rather than using the old 2D architecture.

KEYWORDS: Underwater acoustic sensor network, harmony search algorithm, multi-population, dynamic optimization, pitch adjusting rate.

I. INTRODUCTION

Under the water we are placing the sensors to discover new things or to detect some targets or any other applications (military use, oil spilling, mining...etc). The general structure of underwater acoustic sensor network can be clearly from fig. 1. First the bottom sensor (which is placed at the bed of the ocean), detect the targets and pass the signal to AUV and then to underwater sensor, from that to the surface sink (which is placed at the ocean surface) and then to the base station which is placed at the earth surface.

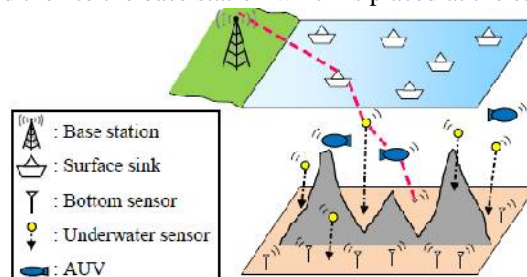


Fig: 1 Illustration of underwater acoustic sensor networks.

II. UASN

Acoustic communication is used to transmit signals in underwater. In fact, radio wave will transmit more than acoustic but in sea water it requires big antennas and high transmitting rate. Optical waves do not support such high transmission rate.

A. CHALLENGES OF UASN

Limited bandwidth, Impaired channel, High Propagation delay, Bit error rate is high, Limited battery power,

Failure of sensors due to fouling and corrosion.

B. APPLICATIONS OF UASN

Ocean sampling networks, undersea explorations, Mine reconnaissance, distributed tactical surveillance, Environmental monitoring, Disaster prevention, assisted navigation.

III. CONTRIBUTION OF THE PRESENT WORK

First, this work considers a dynamic problem. Second positions of some sensors are not fixed the proposed algorithm can dynamically apply the updated positions to make a new sleep schedule.

HARMONY SEARCH ALGORITHM

Musicians play many harmonies, for various combination of music. Harmony search has two different functions they are **Harmony Memory considering Rate (HMCR)** and **Pitch Adjusting Rate (PAR)**.

BASIC HARMONY SEARCH ALGORITHM

Rules for better harmony in music:

1. Selecting any pitch from memory.
2. Selecting adjacent pitch.
3. Selecting any random pitch.

Similar rules for sensor targeting:

1. Selecting any value.
2. Selecting adjacent value.
3. Selecting any random value.

In Fig: 2 it shows the block diagram of harmony search algorithm and how it works based upon the above rules.

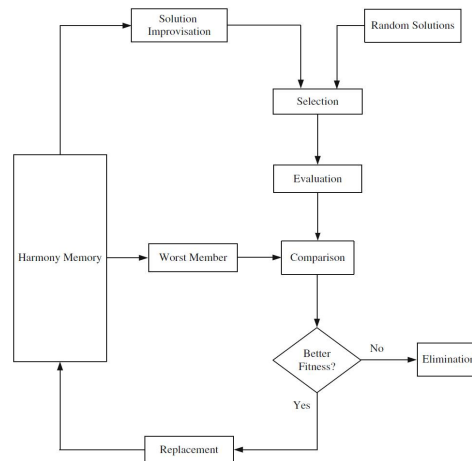


Fig: 2 Harmony Search Algorithm

THE PROPOSED METHOD MPHSA

When compared to genetic algorithm, MPHSA is more advanced. HSA is used mainly for dynamic model.

IV. 3D MODEL

Fig: 3 shows the three dimensional representation of underwater sensor networks. In 3D underwater networks, sensors are allowed to float in water. The sensors are tied with a wire so that the height can be adjusted according to the target.

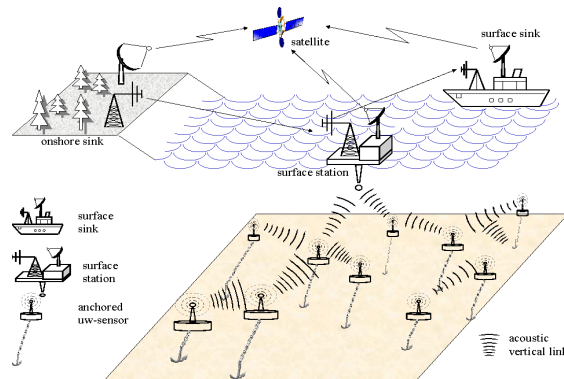


Fig: 3 Three-Dimensional representation of UASN

V. MATHEMATICAL MODEL

Consider in Fig. 4(a), there are 6 number of sensors (s_1-s_6) and 4 number of target ($\pi_1-\pi_4$). Each sensor is arranged in a sphere structure to cover all targets easily. The sensing range size of each sensor may differ due to its heterogeneous sensor type. Base station (BS) is placed, up above the sea level to collect the messages which is transmitted from the sea bed.

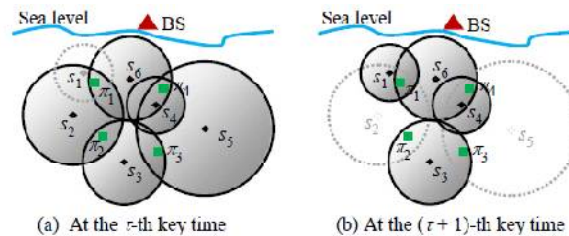


Fig: 4 Example for dynamic UASN at two key times.

At a particular time, each sensor could be in one of four modes: active, asleep, malfunctioned, and dead. Only active sensors will work to detect the targets and consume battery power. To save the battery power, sensors that are not active can be turned off. Sensor may be dead due to battery power depletion, or get lost due to external factors. Sensors that are active or asleep are called as surviving sensors and sensors that are malfunctioned or deadlines are called to fail.

Sensor modes vary, based upon the active sensors vary at each and every time. So, in this work we propose a method to decide a sleep schedule at each and every key time.

As shown in Fig. 5, the 1st key time is the initial time, at which each sensor is works with the initial battery power. Here the sleep schedule is initialised. During the 1st key if some targets are not covered mean the 2nd key time is started.

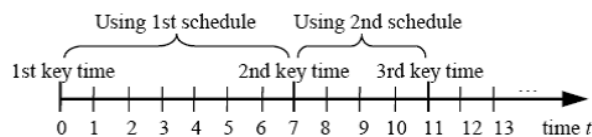


Fig: 5 Relationship between sleep schedule and key time.

At the 2nd key time, the sensors information is updated and sleep schedule is followed to cover all targets.

VI. NOTATIONS USED

S : Set of Sensors, $S = \{s_1, s_2, \dots, s_n\}$

T : Set of Targets, $T = \{\pi_1, \pi_2, \dots, \pi_n\}$

S_τ : Set of survival sensors at the τ -th key time

F_τ : Set of malfunctioned sensors at the τ -th key time

D_τ : Set of dead sensors at the τ -th key time.

R_τ : Set of sensors that are recovered at the τ -th key time.

P_f : Malfunction probability

P_d : Dead probability

P_r : Recovery probability

$S = \{s_1, s_2, \dots, s_n\}$ in a UASN to detect all targets in $T = \{\pi_1, \pi_2, \dots, \pi_m\}$ at different key times. Consider the sleep schedule at the τ -th key time. Initially update the set of survival sensors(S_τ) at τ -th key time.

$$S_\tau = (S_{\tau-1} \cup R_\tau) \setminus (F_\tau \cap D_\tau)$$

VII. MPHSA ALGORITHM

1. At the τ -th key time survival sensors are updated
2. Initialize the parent harmony memory HM.
3. Divide HM into sub-HM (sub-HM1, sub-HM2, ..., sub-HM δ)
4. Initialize the current iteration number as 1 (ie., $\eta = 1, 2, \dots, n$)
5. **if** $\text{rand}(0, 1) < \text{HMCR}$ **then**
6. Choose two harmonies x^{new1} and x^{new2} from sub-HMi
7. **if** $\text{rand}(0, 1) < \text{PAR}(\eta)$ **then**
8. Make a uniform crossover operator on x^{new1} and x^{new2} , and replace the resultant value in the place of x^{new1} and x^{new2} .
9. **end if**
10. Let x^{new} be the one of x^{new1} and x^{new2} with a better fitness value
11. **else**
12. Randomly generate a feasible harmony as x^{new}
13. **end if**
14. If x^{new} is better than worst harmony in sub-HMi, x^{new} replaces it
15. **end for**
16. $\eta = \eta + 1$
17. **end while**
18. Decode the best harmony among all sub-HMi's
19. If number of covers is non zero, randomly choose one of the covers as the output, otherwise output is zero i.e., no solution.

VIII. SIMULATION RESULT

By using different number of sensors and targets we can run the MPHSA algorithm to get various outputs. And the number of iterations can also be extended until we get better solution to detect the target.

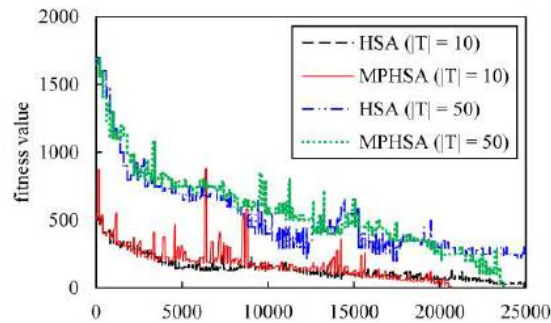


Fig: 6 Experimental comparisons when number of sensors $|S|$ is 10 or 50.

XI. CONCLUSION

In this work we dynamically determined a sufficient number of active nodes in the UASN at different times to develop a sleep scheduling scheme. This work develops a MPHSA which yields better results than Genetic Algorithm. This works considers 3D Architecture of UASNs for more coverage area.

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