Location-Aware Real Time Oceanographic Model to Prevent Coastal Drowning

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Abstract— **A majority ofAsian countries are mainly agricultural economies with abundant water resources including coastal regions. Drowning is the second leading cause of accidental deaths in the world, next to road accidents. In Sri Lanka,approximately 1050 people die annually from drowning. This paper provides a novel approach to identify sea level behavior and predict a safe level of sea depth to swim and bath in coastal areas using a dynamically adjustable linear equation thatfocuses on several related facts affecting the safety of swimmers. Acentralized server based system gathers relevant facts and Buildsa data storage containing above mentioned facts.Auser can directly execute a mobile based application to identify a safety grid around his bathing area using updated weather information. The proposed system will gather relevant environmental data using bathymetric maps, satellite images and online weather stations about the target location. After collecting all relevant data,an oceanographic mathematical model is used to derive the factor of risk for bathinginside the targetarea. The system will then display a safe regionin a grid on the mobile screen to user.**

***Keywords-** linear equation, diving, oceanographic data, drowning*

I. Introduction

According to World Health Organization (WHO),"Drowning is a public health issue that needs worldwide attention. A child drowns every minute in the world and also drowning is the main cause of death next to accidents in children under 5 years of age [1,18]. About 1050 people die annually in Sri Lanka which is several times higher than the number of deaths due to dengue fever.. Most of these deaths are preventable but there is a lack of mechanism to implement a public awareness program to prevent suchstrategies in most of the counties that falls into low middle income levels [16, 17].

A number of facts have contributed to sea drowning in countriessuch as Sri Lanka because of its easy access to abundant waterways and the sea. We identify several important facts to build an information grid around coastal areas to prevent unfortunate sea drowning. The slope type of the coastal area [19], coastal land form[20], type of the beach[21,22],water Level, dangerouscurrents or waves, wind speed and direction[22],climatic cycles, climatic condition of the region [23] are the parameters to be used in this grid[1].Usually sea water level and coastal safety spots for sea bathing change due to above factors rapidly[18]. When a low tide or a high tide occurs in a coastal area, the water level of these fluctuates very rapidly thereby, increasing risk to lives. Most of the developing countries have a problem of having lack of applications or mechanisms to predict most probable coastal safety spots for routine users in real time because of its random behavior.

The main aim of the proposed research is to introduce a novel mechanism to identify coastal safety spots using a dynamically weighted linear equation that returnsthe probability of risk (or danger) arounda specific coastal area and also to implement a central server based system with data mining functionalities combined with a mobile application to identify coastal safety spots for sea bathing.

II. Methodology

The proposed safety coastal spots identification mechanism consists of a server-side backend layer and a mobile interface layer. The mobile application layer passes user data to the server side and displaysthe process data. The server backend layer handles data collection, dataaggregation, image processing, algorithmic solving with data mining and result generation process as shown in Fig. 1.

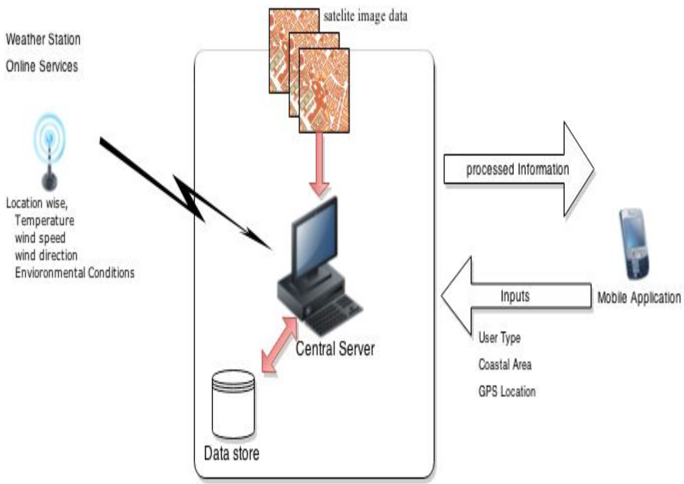


Fig. 1: Systems topology

i. Back End Data Retrieval Process

The core of the proposed system is to capture all weather related data from a user's location using online weather station web services, location-wise past satellite image analysis and create a data store with relevant individual facts. After receiving realistic figures to the server side, all the facts and inserted to the newly created oceanographic model to generate the probability of risk aroundthe coastal sea area where the user intends to have a bath.

We used an open source weather data API called "OpenWeatherMap" to obtain relevant weather data in JSON format by sending users location through API call.

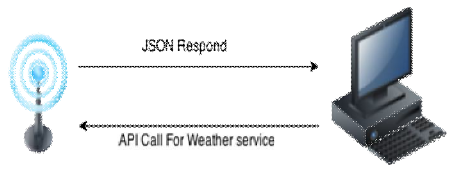


Fig 2: Back-end data retrieval by open source weather API

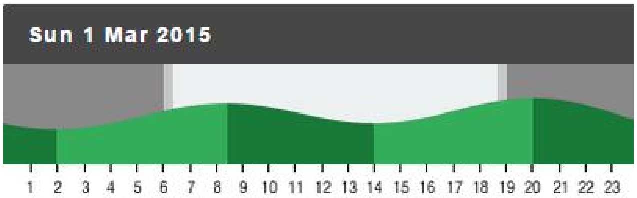
Moreover, we can usebathymetric survey details released by National Aquatic Resources Research and Development Agency (NARA) of Sri Lanka to identify the slope of the sea basin and depth of the target location.

ii. Oceanographic Model Derivation Process

There are several factors to be considered to measure the danger level around coastal areas. We consider the following factors to build the proposed oceanographic model to derive the danger level around coastal area using a grid based system.

- Tidal wave data time series analysis.
- Sea depth using bathymetric data sources.
- Wind wave effect around Sri Lankan coastal area.
- Slope around given sea area using sharpening special filtered satellite images and map data.
- Environmental conditions around target location

a) Depth with tide data



Low	1:56AM	0.7m	First Light	6:01AM
High	8:23AM	1.8m	Sunrise	6:22AM
Low	1:57PM	1m	Sunset	6:40PM
High	7:59PM	2m	Last Light	7:01PM

Fig 3: Tide chart data behavior in Colombo, Sri Lanka [15]

Tidal data chat is a chart that contains time series of information about the behavior of tidalwaves arounda particular country as shown in Fig. 3.

A strong impact in increasing the risk of bathing due to tidal waves is reported in **[13].**The location-wise depth at time t due to tidal waves is calculated as

$$d(x,y,t)= d(x,y)+t(t)$$

where d(x,y) = location wise depth and t(t)= tide chart data of Sri Lanka.

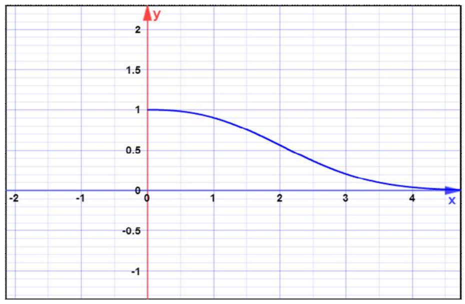


Fig 4: Depth (x=d) vs. safety factor(y=f(d))

The graph shown in Fig. 4 is fitted using interview data gathered from beach life guards.

b) Wind wave effect (chop, swell)

The wave speed, also known as a wind wave,affects creates a huge impact on increasing or decreasing the danger level around the target location**[10, 8]**and is given by,

$V_w(x,y)=$

where $g = 9.8\ ms^{-2}$and V_w= Celerity of the wind wave.

$g(x,y)= 1-(V_w(x,y)/V_{max})$

where$V_{max}=7\ ms^{-1}$

c) Slope fact calculation

If a person does not know how to float on the sea water, then this slope factor will impact heavily on the probability of riskat the target location. In our model, we assume that a proportional relationship between the slop and the danger level. We capture the slope of the target location using a bathymetric map or applying sharpening filters on satellite images of the target area. The slope at a target location (x, y) is given by:

$slope(x,y)= 1-(slope_v/slope_{Max})$

$slope_{max}=0.3$ meters.

Let $f(x) = e$^$(-(x*0.4)^{2.5})$ and R = the rain factor (assume heavy rain will have an impact on sea bathing). Then, the probability of risk of drowning at a particular location (x, y) at time t is given by:

$$P = w_1.f(x, y, t) + w_2.g(x, y, t) + w_3.slope(x, y, t) + R$$

Where w_1, w_2 and w_3 are associated weights for depth, wind wave speed and slope of the land, respectively.Also, $(w_1, w_2, w_3) \in [0, 1]$.

III. Results and Discussion

As seen in Fig. 5, a grid with several depths is created to simulate the model outcome for each location. For instance, we use 2, 3(x, y) geographical point data collected from satellite images or bathymetric detail maps (positive depths are for ground level and negatives are for sea area).

In order to generate a tidal effect with time factor, we express

$$d(x, y, t) = d(x, y) + 1.2\sin((t/12)*2*\pi + \alpha)$$

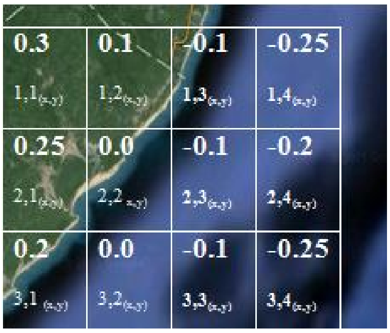


Fig 5: Depth data around target coastal area

For simplicity we assume α =0.0 and we take bathing time as 6h.

$$d(2,3,6h)= d(2,3)+ 1.2\sin((6/12)*2*\pi + 0.0) = d(2,3)+0 = -0.1$$

For the actual depth take $|d(2,3,gh)|=0.1$

Then, $f(d) = e\wedge(-(d*0.4)^{2.5}) = e\wedge(-(0.1*0.4)^{2.5}) = 0.98$

Also, $V_w(d) = \text{sqrt}(g*d) = \text{sqrt}(9.8*0.1)=0.98$ and

$g(d)= 1-(V_w(x,y)/V_{max}) = 1-(.98/7)=\mathbf{0.85}$

The slope for the model is calculated as:

$$slope = slope_x + slope_y$$
$$= \alpha(d(x+1,y) - d(x, y)) + \beta(d(x,y+1) - d(x,y))$$

where $\alpha, \beta = 1$.

Hence,

the slope value $= 1((-0.2)-(-0.1))+1((-0.1)-(-0.1)) = -0.1$

The actual value of the slope = 0.1. The slope at (x, y) is given by:

$slope(x,y) =1-(0.1/0.3) = \mathbf{0.66}$

For the place known as Hikkaduwa in Sri Lanka (latitude = 6.11, longitude= 80.11), the rainfall is generated by a weather API (http://api.openweathermap.org/data/2.5/weather?lat=6.11&lon=80.11)

Consequently, the probability of risk is calculated as:

$$P = w_1*0.98+w_2*0.85+w_3*0.66+ R_i$$

Where, depending on the environmental condition, R_1 = light rain, R_2 = heavy rain (assuming heavy rain having a profound effect on sea bathing) and R_3 = sunny day.

if P> 1 then probability of risk = 1

if P< 0 then the probability of risk = 0

else P = probability of risk

IV. Mobile Integration

A mobile application is developed to visualizethe server-side processed data for users in a convenient manner.

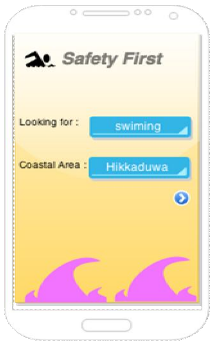


Fig 6: User selects preferred coastal area from mobile application

When a user selectsa preferred area (as seen in Fig. 6), the system will automatically find the relevant GPS location and sends it to the central server.The server in turn utilizesthe relevant data store and weather API to capture all facts and environmental conditions to be applied on theproposed oceanographic model to calculate a factor of risks around the target location and display the information on a grid on the user's mobile display as given in Fig. 7.

Fig 7: Grid based layout showing risk levels around a target coastal area

III. CONCLUSION

The novelty of the project is the application of an oceanographic model to generate a probability of risk associated with drowning in coastal areas in Sri Lanka and identify safety spots for bathing.In this research, we used a limited number of parameters to generatethe slope of the location, wind wave speed, wind wave direction, depth, environmental conditions and tidal data. However, according to oceanography and hydrodynamics, more factors need to be considered to arrive at a comprehensive conclusion.

Future research directions may involve testing the proposed model around Sri Lanka as well as in other countries and include more facts (i.e. location-wise fixed-rip current details, river depositor spots, diverse behavior of sea waves, etc.).

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