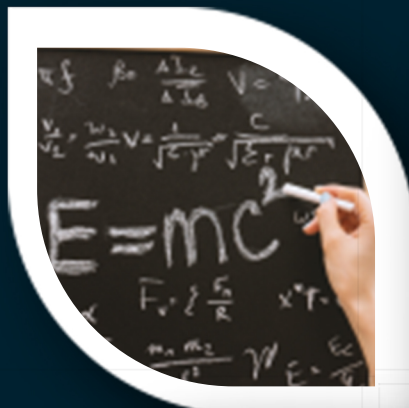


SSSTJ



Suan Sunandha Science and Technology Journal
Volume 6, Number 2, July 2019



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Applying STELLA model to optimize land allocation in watershed based on DO and BOD dynamics

Treeranut Srisunont^{1*}, Sittichai Tantanasarit², Chayarat Srisunont³

¹Faculty of Science and Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani 13180, Thailand

²Faculty of Forestry, Kasetsart university, Bangkok 10900, Thailand

³Faculty of Science and Technology, Bansomdejchaopraya Rajabhat University, Bangkok 10600, Thailand

Corresponding author e-mail: *treeranut@vru.ac.th

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Abstract: Urban expansion with intensive and improper plan of land use can cause water deterioration along the watershed. This study aimed to find optimization of land allocation for sustainable development without water pollution in the Trang watershed, located in Nakhon Si Thammarat and Trang Province, Thailand by using STELLA software. Dissolve oxygen (DO) and biological oxygen demand (BOD) were used as water quality parameter to indicate water deterioration. Changes of DO and BOD over time in the study area were developed by STELLA. Then, they were simulated from scenario with variation in percentage of land use types: forest (Fo), agriculture (Ag), urban (Ur) and industry (In). Results revealed that the correlation between the simulated and observed values of DO and BOD was in good agreement. The simulation of scenarios showed that when percentage of Ur and In were less than 5 or the percentage of Fo and Ag were larger than 95, water will be very clean ($DO > 6$ mg/L and $BOD < 1.5$ mg/L). Higher Ur and In, reduction of DO and increasing of BOD were found in this study. Water would be deteriorated ($DO < 2$ mg/L and $BOD > 4$ mg/L) when In and Ur were more than 25%. The model developed by STELLA could be used to describe DO and BOD variation over time and help in finding optimization of land allocation without disturbing the water quality in Trang watershed. Furthermore, the model can be applied in other watersheds for sustainable land development.

Keywords: STELLA, land use, optimization, DO, BOD

1. Introduction

Water quality can be deteriorated by human activity such as domestic use, agriculture, industry, power generation, and forestry practices (Carr and Neary, 2008; Nas et al., 2008). Land use activities are one of the major causes of deterioration of water especially intensive and improper development: urbanization, industrialization, and agricultural activities (Ren et al., 2003; Kannel et al., 2007; Lee et al., 2007; He et al., 2008; Tu, 2008; Liu and Li, 2009; Rothenberger et al., 2009; Gyawali, 2013). Trang watershed was chosen as representative of watershed with good water quality and low development area (Pollution Control Department, 2011). The watershed is possibly arranged the optimization of land allocation with proper development. Otherwise, water pollution can be occurred. Thus, pollution management requires a better understanding in the impact of land use variation on water quality.

In this study, Dissolve Oxygen (DO) and Biological Oxygen Demand (BOD) were considered as important water parameters that

directly affect from land use (Fan and Wang, 2008; Tu, 2008). DO has been used for design and operation of industrial and municipal treatment plants while representing the overall health of an aquatic ecosystem (Zhang, 2012). Large input of organic wastes can boost bacteria growth which oxygen is required to decompose a certain amount of organic waste (Toma, 2012). This phenomenon can be described as BOD. Subsequently, the more bacteria use up oxygen in the water, thus leaving the water "oxygen depleted" that the water may not be able to support aquatic life. DO concentrations less than 5 mg/L can create significant problems in the growth or even survival of fish, and 2 mg/L is the threshold concentration below which aquatic organisms can no longer survive (Cox, 2003; Chang, 2005; Garg, 2006). Thus, DO and BOD are valuable parameters describing amount of organic waste in water caused by activities on land.

STELLA or Structural Thinking Experimental Learning Laboratory with Animation is a software package that has been widely used in biological, ecological, and environmental sciences (Hannon

and Ruth, 1994; Peterson and Richmond, 1996; Costanza et al., 2002; Aassine and Jai, 2002; Ouyang, 2008). STELLA program can predict the direction of development in watershed while other models cannot predict the direction of development. It only can evaluate distance between point source and point affect. The STELLA program is a user-friendly that allows the user to simulate systems without any advanced programming language just only clarify conceptual model. The user can create an iconographic interface to facilitate the construction of dynamic system models which are diagrams of the interrelationships between the components of a model that describes the problem of interest, and then solves it numerically (Iseesystems, 2014; Ouyang et al., 2010). Due to these advantages, STELLA was used in this research.

Objectives of this study were: (1) to develop a system dynamic model for describing the DO and BOD variation over time in Trang watershed using STELLA program and (2) to find optimization of land allocation for sustainable development without water pollution. Then by the simulated model and its predictions the land development capacity in the watershed which is the optimum ratio of land use types for forest, agriculture, urban and industry that would support a healthy water quality was achieved. Finally, our results suggested that STELLA can be used as practical tool for water quality management in order to achieve sustainable development and protect the environment with visualize of complex dynamic systems.

2. Materials and methods

2.1 Study area

The study was conducted at Trang watershed which located in southern part of Thailand (Figure 1). The watershed is about 130 km long from north to south and total area is about 3,435.57 km². Trang watershed is one of the most important rivers of Trang Province which originates from Khao Luang range mountain in the Nakhon Si Thammarat Province and flows through Thung Song municipality before into the outlet part in Kantang District, Trang Province. It receives pollution loads from both point and nonpoint sources. The climate of the basin is influenced by two seasonal monsoons as well as tropical depressions and temperature of the area which varies between 27.15

°C and 28.68 °C throughout the year. In the watershed, more than 73% of area is covered by agricultural land use, whereas only 18% forest land is located mostly in mountainous areas and around boundary of watershed.

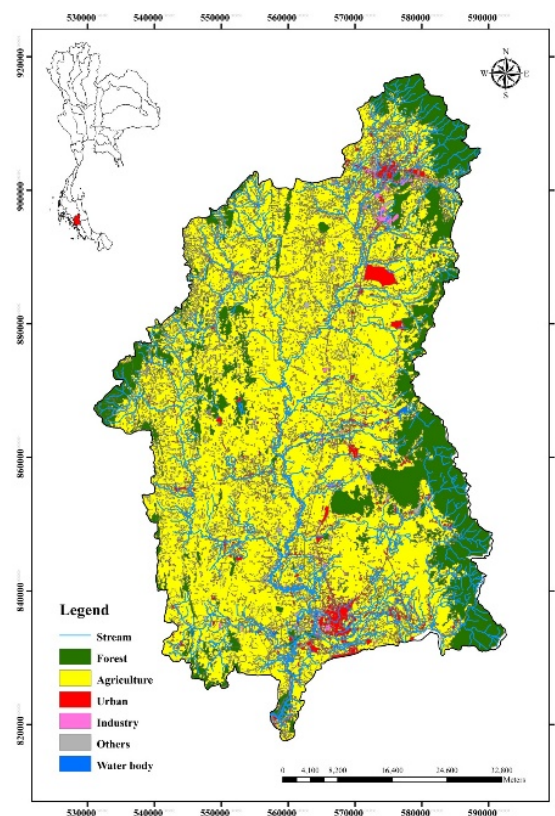


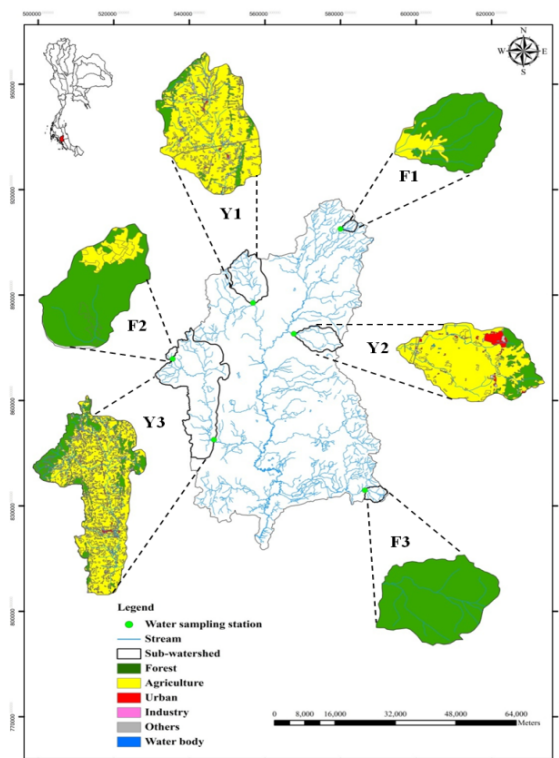
Figure 1. Land use in Trang watershed.

2.2 Data collection

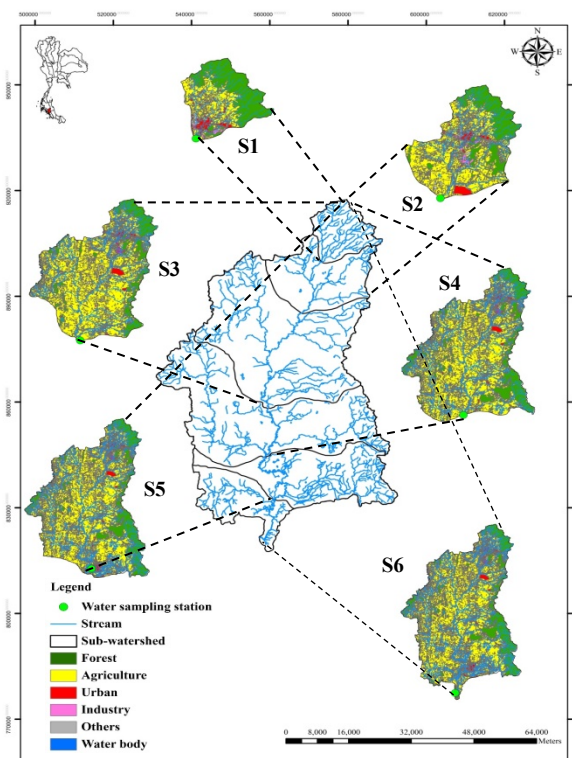
The study area was divided into 12 sub-watershed stations (forest sub-watershed = F1, F2, F3, agriculture sub-watershed = Y1, Y2, Y3 and mainstream sub-watershed = S1 to S6) (Figure 2 (a) and (b)). Each station, Dissolved Oxygen (DO), Biochemical Oxygen Demanded (BOD), temperature, pH, Electrical Conductivity (EC) and turbidity were collected in year 2011 and were analyzed by descriptive statistics. The categories of land use in year 2010 were interpreted by GIS technique consist of percentages of land use types: Forest (Fo), Agriculture (Ag), Urban (Ur), Industry (In), Others (Ou) and Water body (Wa), provided by Land Development Department, Thailand. Population Density (PD) in each sub-watershed was analyzed from Provincial Administration Department, Thailand. Then, the relationship between percentages of land uses and water quality

parameters in each sub-watershed were analyzed. Pearson correlation coefficient (r_{xy}) was used to evaluate the strength of the relationship. Finally, DO and BOD concentrations were simulated by

using multiple regression analysis to input in STELLA as DO_{reg} and BOD_{in} , respectively. The regression equations were compared with determination coefficient (R^2) values.



(a) forest and agriculture sub-watershed



(b) mainstream sub-watershed

Figure 2. 12 Sub-watersheds in Trang Watershed.

2.3 Model development by STELLA

2.3.1 Model conceptualization

The conceptual model of DO and BOD changes over time consists of reoxygenation and deoxygenation processes (applied from Toma, 2012) as shown Figure 3. Reoxygenation is the exchange of oxygen between atmosphere and water surface, result in oxygen mixed into the water. Reoxygenation rate (k_2) was calculated by velocity and depth. In This study, dissolved oxygen regression (DO_{reg}) was simulated by multiple regression analysis as described in previous section. Deoxygenation that decreases the dissolved oxygen by bacterial activity referred as BOD in the water. The reduction rate of DO is presented as k_1 .

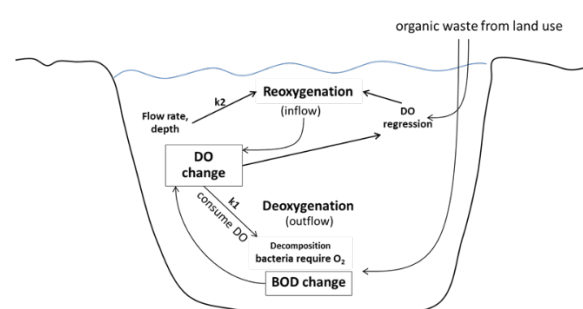


Figure 3. The conceptual model of DO and BOD change over time.

2.3.2 Model construction by STELLA

The model was applied to 12 sub-watersheds for prediction DO and BOD in Trang watershed by STELLA (Figure 4). The model was constructed using the four components (1) DO and BOD storages (2) DO inflow (3) BOD inflow and (4) DO and BOD outflows (applied from Feng et al., 2012; Mandal et al., 2012; Bulagao et al., 2013).

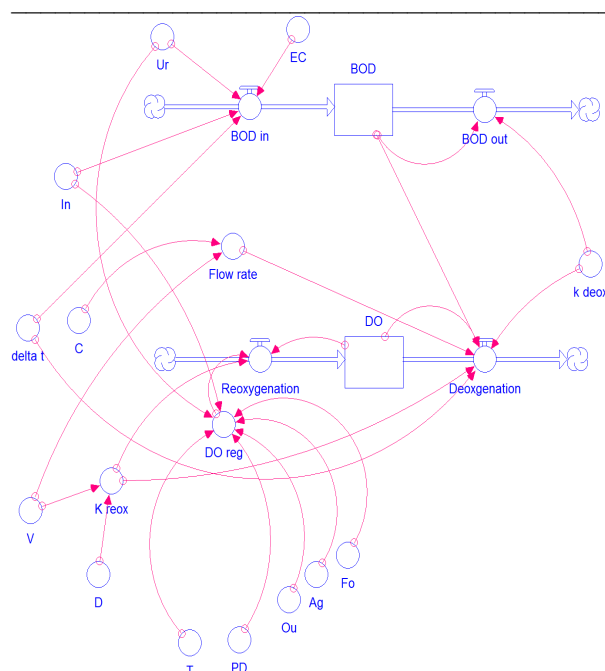


Figure 4. Flow diagram of DO and BOD in Trang Watershed using STELLA

DO and BOD storage

The model considered two processes that affect the DO level which were reoxygenation and deoxygenation as equation 1.

$$\frac{dDO}{dt} = \text{reoxygenation} - \text{deoxygenation} \quad (1)$$

Where: DO is the concentration of dissolved oxygen (mg/L); t is time (month); reoxygenation and deoxygenation are the main processes affecting the DO balance; reoxygenation based on the data from multiple regression analysis as the water is affected by % land use; deoxygenation is to consume DO in the river through the consumption of the organic waste. BOD storage was calculated by equation 2.

$$\frac{dBOD}{dt} = BOD_{in} - BOD_{out} \quad (2)$$

Where: BOD is the concentration of biochemical oxygen demand (mg/L); t is time (month); BOD_{in} and BOD_{out} are the main processes affecting the BOD balance. BOD_{in} is increased naturally in the river when organic matter flows into the system, which was estimated by result of analysis correlation section in this study. BOD_{out} is consumed by decomposition that equals the reduction of DO.

DO inflow

DO inflow is reoxygenation process. It was determined by a reoxygenation coefficient (K_{reox}) multiply with the difference between DO

regression and the actual dissolved oxygen concentration (McCutcheon, 1989) as equation 3.

$$\text{Reoxygenation} = K_{reox}(DO_{reg} - DO) \quad (3)$$

Where: DO_{reg} is DO regression (mg/L); and, DO is the dissolve oxygen concentration (mg/L).

Reoxygenation coefficient (K_{reox}) was determined by equation 4 (O'Connor and Dobbins, 1958).

$$K_{reox} = 1.72 V^{0.5} / D^{1.5} \quad (4)$$

Where: V is river velocity (m/s); and, D is river depth (m).

DO regression (DO_{reg}) was estimated by multiple regression as equation 5.

$$DO_{reg} = 0.041(\%Fo) + 0.043(\%Ag) - 0.538(\%Ur) + 1.169(\%In) - 0.173(\%Ou) + 0.003(PD) - 0.023(T) + 3.588 \quad (5)$$

Where: %Fo is percentage of forest land; %Ag is percentage of agriculture land; %Ur is percentage of urban land; %In is percentage of industrial land; %Ou is percentage of other land; PD is population density (person/km²); and, T is temperature (°C).

BOD inflow

BOD inflow (BOD_{in}) was estimated by multiple regressions as equation 6.

$$BOD_{in} = 0.21(\%Ur) + 0.55(\%In) + 0.012(EC) + 0.191 \quad (6)$$

Where: % Ur is percentage of urban land; %In is percentage of industry land; and, EC is electric conductivity (μmho/cm).

DO Outflow

DO outflow is deoxygenation reaction. The dissolved oxygen that depleted by **microbacteria** consumption, represent as DO_{out} (mg/L) as shown equation 7.

$$DO_{out} = k_{deox} BOD \quad (7)$$

Where: k_{deox} is deoxygenation coefficient; and BOD is concentration of biochemical oxygen demand (mg/L).

BOD outflow is the rate of BOD decrease when amount of BOD in the water is decomposed by bacteria, represent as BOD_{out} (mg/L) as shown equation 8.

$$BOD_{out} = k_{deox} BOD \quad (8)$$

Where: k_{deox} is deoxygenation coefficient; and, BOD is concentration biochemical oxygen demand(mg/L).

2.3.3 Model calibration and validation

The calibration of DO and BOD model developed from STELLA was run using observed value of each sub-watersheds in year 2011 and k_{deox} was used within range of 0.1-0.3 (Nemerow, 1991; Chapra, 1997). The parameters defined in the model calibration are shown in Table 1. The program run until its simulation similar conditions had good agreement with the observe value of DO and BOD data. A model calibration sequence was started with the changes of DO and BOD in average yearly data and then average monthly

calibration compare with determination coefficient (R^2) values. Model validation was tested by two methods using STELLA program, the model was validated using the data from 12 sub-watersheds in year 2014 at the same water sampling in 2011, the model was validated using other sub-watershed (C1 and C2) data in year 2014 for development in other watershed (Figure 5). However, the model collect data in year 2010 and 2011 for calibration, then validation in year 2014, if model high accuracy in result that mean the model can apply or predict other watershed in future, if we use this method.

Table 1. The result of parameters defined in the model calibration.

Parameters	Unit	Symbols	Range	Verified	References
1. DO and BOD storage					
1.1 Dissolved oxygen	mg/L	DO	Varied	DO values in field	Field survey
1.2 Biochemical oxygen demand	mg/L	BOD	Varied	BOD values in field	Field survey
2. DO inflow					
-	-	Reoxygenation	-	-	McCutcheon, 1989
2.1 DO regresstion	mg/L	DO _{reg}	-	Actual values in field	This study
1) Percentages of forest land	%	%Fo	Varied	Actual values in field	This study
2) Percentages of agricultural land	%	%Ag	Varied	Actual values in field	This study
3) Percentages of urban land	%	%Ur	Varied	Actual values in field	This study
4) Percentages of industrial land	%	%In	Varied	Actual values in field	This study
5) Percentages of open undeveloped land	%	%Ou	Varied	Actual values in field	This study
6) Population density	person/km ²	PD	Varied	Actual values in field	This study
7) Temperature	°C	T	Varied	Actual values in field	Field survey
2.2 Reoxygenation coefficient	m s ⁻¹	K _{reox}	-	-	O'Connor&Dobbins, 1958
1) River velocity	m s ⁻¹	V	Varied	Actual values in field	This study
2) River depth	m	D	Varied	Actual values in field	This study
3. BOD inflow					
-	-	BOD _{in}	-	-	Streeter&Phelps, 1925
3.1 Percentages of urban land	%	%Ur	Varied	Actual values in field	This study
3.2 Percentages of industrial land	%	%In	Varied	Actual values in field	This study
3.3 Electrical Conductivity	µmho/cm	EC	Varied	Actual values in field	Field survey
4. DO and BOD outflows					
-	-	Deoxygenation	-	-	Streeter&Phelps, 1925
4.1 Deoxygenation coefficient	days ⁻¹	k _{deox}	0.1-0.3	Varied	Chapra, 1997
4.2 Flow rate	-	-	-	-	This study
1) River cross section	m ²	C	Varied	Actual values in field	This study
2) River velocity	m s ⁻¹	V	Varied	Actual values in field	This study
5. Other parameters					
5.1 Delta t	t	t	-	0.25	This study

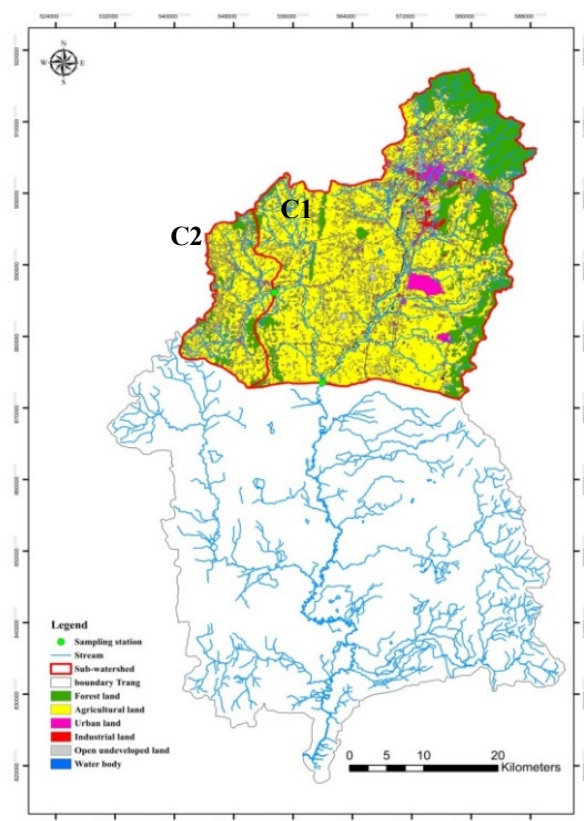


Figure 5. The other sub-watershed (C1 and C2) for model validation

2.4 Scenario

The objectives of scenarios were to find the suitable development plan which DO and BOD could meet the standard and classifications. Scenario was simulated in the sub-watershed (C2) because it was not in the conservation area with low urbanization. The STELLA model simulated five years (2014-2018). DO and BOD change over time. Scenarios of planning approach were varied by percentage of land use; Fo, Ag, Ur and In. Scenarios were divided into four methods. First, all of four parameters had different percentages of land use types (total scenarios was 24 scenarios). Second, there were two parameters that had equal percentages of land use types (total scenarios was 60 scenarios). Third, there were three parameters that had equal percentages of land use types (total scenarios was 25 scenarios). Finally, the new idea of combination percentages of urban and industry were 5, 10 and 15 (total scenarios was 186 scenarios).

3. Results and discussion

3.1 Correlation analysis

Results from the Pearson correlation coefficients (r_{xy}) found that percentage of land-use types were significantly correlated with DO and BOD in the sub-watershed as shown in Table 2. First of all DO had significant negative correlation with Ag, Ur and In ($r_{xy} = 0.86, 0.86$ and 0.85 , respectively). DO had significant positive correlation with Fo, Ou ($r_{xy} = 0.90$ and 0.71 , respectively). Population density (PD) was significantly negative correlation with DO ($r_{xy} = 0.78$). Considering water parameters, DO had significant negative correlation with temperature and EC ($r_{xy} = 0.90$ and 0.98 , respectively). While, BOD had significant positive correlation with Ur, In and EC ($r_{xy} = 0.68, 0.73$ and 0.69 , respectively). These correlations were significant at P-value < 0.05 .

Result showed that in Trang watershed, DO and BOD were affected by agriculture, urban and industry activities. These results suggest that urban and industry expansion could be the primary driving forces in DO. Therefore, expansion of urban and industry were generally associated with poor water quality in DO. Urban land has the potential to generate large amount of pollution from waste discharge (Basnyat et al., 1999; Zampella et al., 2007; Li et al., 2009; Katarzyna et al., 2016; Muhammad et al., 2018). Tu (2008) reported that urban lands were usually related to be the causes of poor water quality. Similarly, BOD had significant positive correlation with urban, industry. Urban and industry expansions cause increasing in BOD. Likewise, Yingrong et al. (2017) reported that increasing in BOD will have to make treatment from 1.1 billion in 2000 to 2.5 billion in 2050 due to increasing urbanization. Thus, results suggest that urbanization is a major factor that has led to the decrease DO and increase BOD in water. In contrast, the agricultural land did not show any positive relationship with BOD. Normally traditional agricultural practices cause excess amount of BOD. However, the dominate agriculture activities in Trang watershed was Para rubber plantation which is commercial forest unlike others. These lands are not open for surface runoff resulting low BOD. This might be the reason that

agriculture have not acted as the source of pollution in Trang watershed.

Result showed that agricultural land decreased whereas urban land increased. Urban areas are primarily located along the river networks in the Trang watershed, and their impacts on the water quality in watershed were expected. Urban expansion related to the increasing residential, commercial, and industrial lands, and population density in suburbs (Xian et al., 2007). It was clear

that water degradation have been highly influenced by the pollution from point sources as well as non-point sources, which are commonly associated with urbanized areas. Result also showed that the extent of forest land coverage had effect on water quality. In this study, forest land had positive correlation with DO. Extant forest area can cause increasing in DO. Thus, it is used as protector of water quality of Trang watershed.

Table 2. Pearson correlation coefficients between %land use type, among water qualities and, population density with water DO and BOD parameters.

	DO	%Fo	%Ag	%Ur	%In	%Ou	%Wa	BOD	PD	EC	Tur	pH	T
DO	1.00												
%Fo	0.90	1.00											
%Ag	-0.86	-0.99	1.00										
%Ur	-0.86	0.75	-0.81	1.00									
%In	-0.85	0.62	-0.72	0.87	1.00								
%Ou	0.71	0.24	-0.29	-0.04	0.31	1.00							
%Wa	0.16	-0.05	-0.05	0.35	0.35	0.13	1.00						
BOD	-0.81	0.05	-0.23	0.68	0.73	0.16	-0.28	1.00					
PD	-0.78	-0.49	0.27	0.87	0.84	0.31	0.61	0.39	1.00				
EC	-0.98	0.88	-0.86	0.75	0.44	-0.11	-0.03	0.69	0.08	1.00			
Tur	-0.09	0.05	0.02	-0.48	-0.51	0.23	-0.31	0.12	-0.65	0.42	1.00		
pH	0.20	-0.30	0.20	0.15	0.33	0.04	0.69	-0.31	-0.26	0.39	0.35	1.00	
T	-0.90	-0.09	0.03	0.26	0.07	-0.15	0.90	0.08	0.69	0.23	0.19	0.14	1.00

Note: Bold ($P < 0.05$)

3.2 Multiple regression analysis

In this study, after found factor affecting DO and BOD, the sub-watershed was used to link factors (land uses, water quality and population density) with DO and BOD by multiple regression analysis. In this study, Adjusted R^2 was used to select the appropriate regression model. The data

set of annual year 2011 to select the best one of DO and BOD models as shown in Table 3. Result showed value of observed and estimated DO and BOD with R^2 (0.97 and 0.70). Therefore, the predicted model of DO and BOD could be accepted. It indicated that DO and BOD can be estimated by multiple regression analysis in Trang watershed.

Table 3. Multiple regression equations of DO and BOD models.

Equations	(R^2)	
$DO = 0.041(\%Fo) + 0.043(\%Ag) - 0.538(\%Ur) + 1.169(\%In) - 0.173(\%Ou) + 0.003(PD) - 0.023(T) + 3.588$	0.97	(9)
$BOD = 0.28(\%Ur) + 0.04(\%In) + 0.012(EC) + 1.32$	0.70	(10)

3.3 Model calibration

3.3.1 Model calibration of DO and BOD for average year value

The conceptual model of DO and BOD results revealed that the correlation between the simulated and observed values of DO and BOD in average yearly calibration for 12 sub-watersheds

during year 2011 was shown in Figure 6. The slopes of the correlation line for 12 sub-watersheds were close to 1 and correlation (R^2) was close to 0.94 and 0.96, indicating a good agreement between predicted and observed values. Therefore, the model can predict the average yearly value of DO and BOD change overtime in Trang watershed.

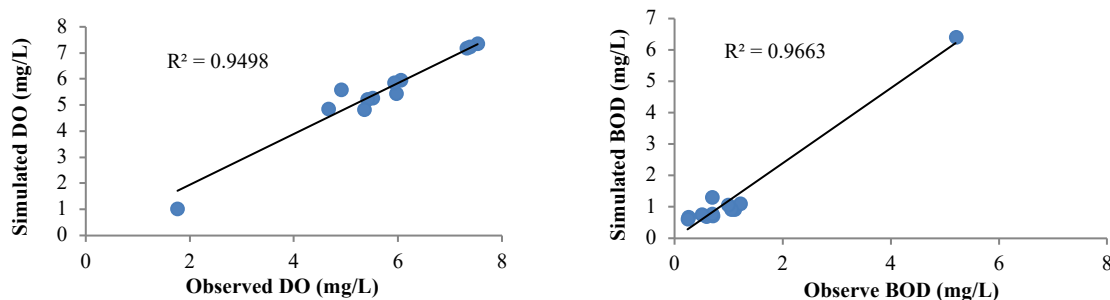


Figure 6. Correlation between simulated and observed values of DO and BOD in average yearly calibration for 12 sub-watershed during year 2011.

For parameters of DO inflow, BOD inflow and DO and BOD outflows processes, actual values in field of each sub-watershed were used in model calibration as shown in Table 1. Except the model parameters of k_{deox} which were adjusted to 0.3 for forest and agriculture sub-watershed (F1, F2, F3, Y1, Y2 and Y3) and 0.1 for mainstream sub-watershed (S1 to S6).

3.3.2 Model calibration of DO and BOD for average month value

Results of the simulated and observed values of DO and BOD changes over time in average monthly calibration for 12 sub-watersheds during year 2011 were shown in Figure 7. The simulated DO and BOD in average monthly calibration could not fit exactly with the observed DO and BOD results; however, the model showed a reasonable good trend of DO and BOD changes overtime. This also indicated that the model can possibly predict the trend of average monthly variation of DO and BOD overtime in Trang watershed.

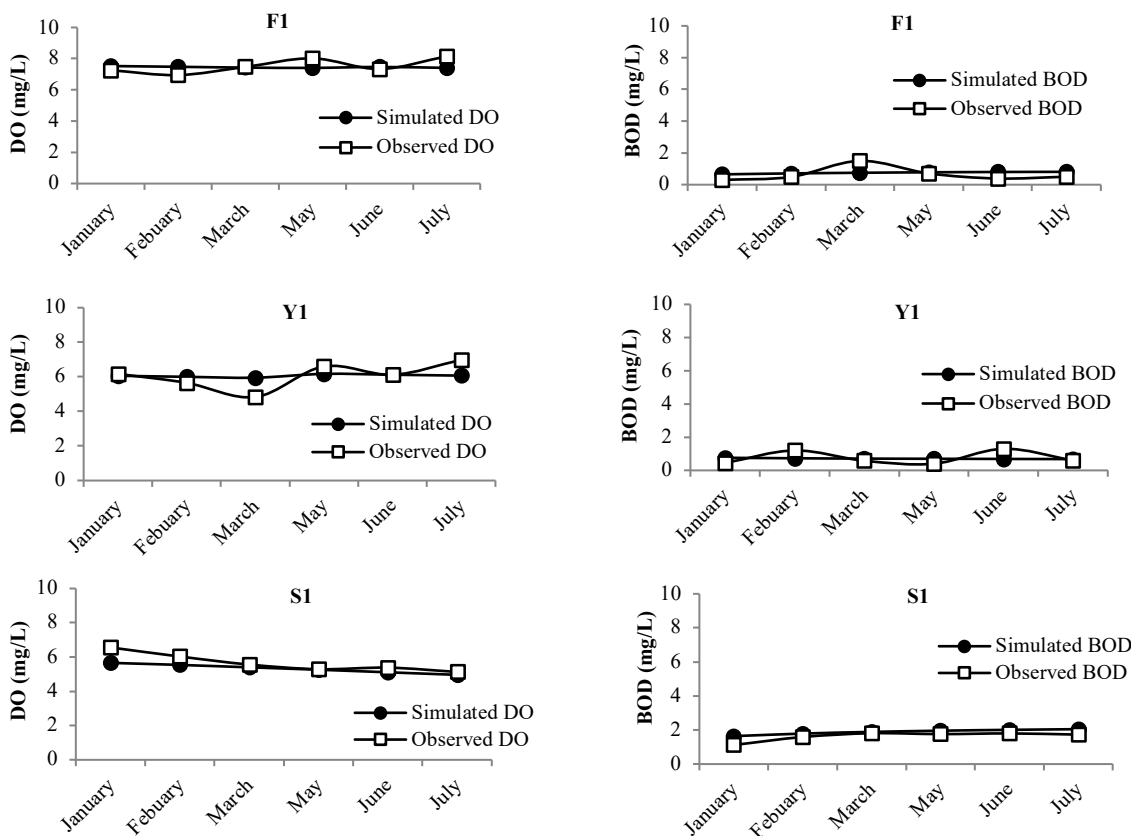


Figure 7. Simulated and observed values of DO and BOD change overtime in average monthly calibration for 12 sub-watershed during year 2011.

3.4 Model validation

3.4.1 Model validation of DO and BOD for average year value

Results revealed that the correlation between the simulated and observed values of DO and BOD in average yearly validation for 12 sub-watersheds

during year 2014 was shown in Figure 8. The slopes of the correlation line for 12 sub-watersheds were close to 1 and correlation (R^2) was close to 0.90 and 0.97, which supported a good model validation. Therefore, the model can predict the average yearly values of DO and BOD changes overtime.

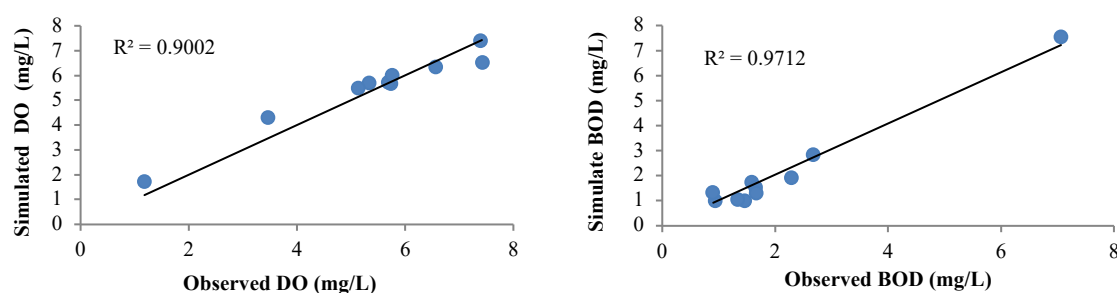


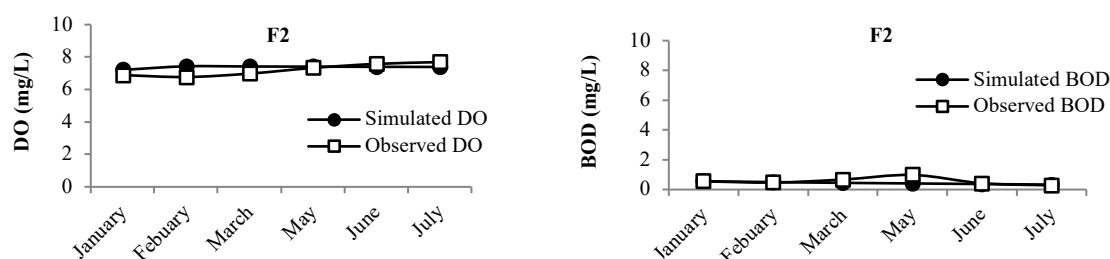
Figure 8. Correlation between simulated and observed values of DO and BOD in average yearly validation for 12 sub-watershed during year 2014.

For parameter of DO inflow, BOD inflow and DO and BOD outflows processes, an actual value in field of each sub-watershed were used in

model validation as shown in Table 1. Except the model parameters of k_{deox} which were adjusted by 0.3 for forest and agriculture sub-watershed (F1, F2, F3, Y1, Y2 and Y3) and 0.1 for mainstream sub-watershed (S1 to S6).

3.4.2 Model validation of DO and BOD for average month value

Results of the simulated and observed variation values of DO and BOD over time in average monthly validation for 12 sub-watersheds during year 2014 were shown in Figure 9. The model shows a reasonable good trend of DO and BOD variation overtime, which also supported a good model validation. Hence, this confirmed that the model can possibly predict the trend of DO and BOD changes overtime in Trang watershed.



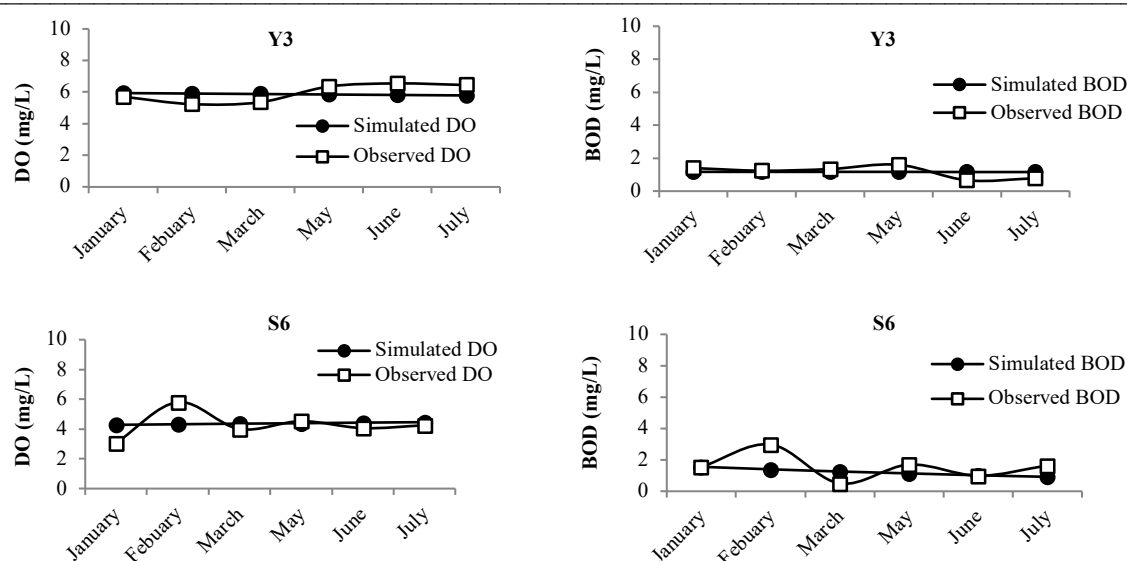


Figure 9. Simulated and observed values of DO and BOD change overtime in average monthly validation for 12 sub-watershed during year 2014.

3.4.3 Model validation for C1 and C2

The comparison of simulated and observed values of DO and BOD change over time in model validation for other watersheds (C1 and C2) were shown in Table 4. Standard Deviation (SD) was used to compare between observed and simulated in DO and BOD. Table 4 shows results of SD which are less different (0.08, 0.06 and 0.24). Thus, the observed and simulated values of the DO and BOD in C1 and C2 were in good agreement. It can be seen the trend between observed and simulated of DO and BOD change overtime. Therefore, the developed model in this study could

be used to describe the DO and BOD change over time in other watershed. This indicated that this model could be used to find suitable development plan in Trang and other watershed.

3.4 Model validation

The objective of this scenario is to find the optimization of land allocation for suitable development plan which DO and BOD meet in the standard and classifications by STELLA program. The scenario planning approach was applied to the study area of the sub-watershed (C2) as shown in Table 5.

Table 4. Result of model validation for prediction in other watersheds (C1 and C2).

Sub-watershed	Month	DO (mg/L)		BOD (mg/L)	
		Simulated	Observed	Simulated	Observed
C1	January	6.03	5.77	1.89	2.39
	February	5.98	6.1	1.84	2.11
	March	5.94	5.35	1.79	1.88
	May	5.89	6.49	1.75	1.77
	June	5.85	6.35	1.72	1.64
	July	5.81	6.10	1.68	1.54
Average		5.92	6.03	1.78	1.89
SD		0.08		0.08	
C2	January	6.27	6.27	1.55	1.68
	February	6.23	6.12	1.4	1.75
	March	6.2	6.63	1.26	1.03
	May	6.16	5.88	1.13	1.65

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	June	6.14	6.15	1.02	1.85
	July	6.11	6.58	0.92	1.35
Average		6.19	6.27	1.21	1.55
SD		0.06		0.24	

Table 5. Estimated DO and BOD from scenarios using C2 sub-watershed.

%Fo	%Ag	%Ur	%In	%Fo+%Ag	%Ur+%In	DO	BOD	Water Quality
0	0	100	0	0	100	0.00	22.52	Deteriorated
0	0	75	25	0	100	0.00	17.52	Deteriorated
5	5	70	20	10	90	0.00	16.18	Deteriorated
10	10	70	10	20	80	0.00	15.85	Deteriorated
5	20	70	5	25	75	0.00	15.68	Deteriorated
20	5	70	5	25	75	0.00	15.68	Deteriorated
20	5	65	10	25	75	0.00	14.68	Deteriorated
5	20	65	10	25	75	0.00	14.68	Deteriorated
10	15	65	10	25	75	0.00	14.68	Deteriorated
15	10	65	10	25	75	0.00	14.68	Deteriorated
20	10	65	5	30	70	0.00	14.52	Deteriorated
10	20	65	5	30	70	0.00	14.52	Deteriorated
15	15	55	15	30	70	0.00	12.52	Deteriorated
20	20	50	10	40	60	0.00	11.18	Deteriorated
25	25	50	0	50	50	0.00	10.85	Deteriorated
30	30	30	10	60	40	0.91	6.52	Deteriorated
70	5	20	5	75	25	1.43	4.02	Deteriorated
10	65	20	5	75	25	1.49	4.02	Deteriorated
5	70	20	5	75	25	1.52	4.02	Deteriorated
75	10	12	3	85	15	3.62	2.08	Fairly clean
70	15	12	3	85	15	3.63	2.08	Fairly clean
80	5	12	3	85	15	3.63	2.08	Fairly clean
85	0	12	3	85	15	3.63	2.08	Fairly clean
60	25	12	3	85	15	3.65	2.08	Fairly clean
65	20	12	3	85	15	3.66	2.08	Fairly clean
55	30	12	3	85	15	3.68	2.08	Fairly clean
50	35	12	3	85	15	3.69	2.08	Fairly clean
35	50	12	3	85	15	3.84	2.08	Fairly clean
30	55	12	3	85	15	3.85	2.08	Fairly clean
45	40	12	3	85	15	3.85	2.08	Fairly clean
40	45	12	3	85	15	3.87	2.08	Fairly clean
10	75	12	3	85	15	3.89	2.08	Fairly clean
25	60	12	3	85	15	3.89	2.08	Fairly clean
20	65	12	3	85	15	3.91	2.08	Fairly clean
15	70	12	3	85	15	3.92	2.08	Fairly clean
85	5	8	2	90	10	4.86	1.12	Medium clean
90	0	8	2	90	10	4.87	1.12	Medium clean

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40	50	8	2	90	10	4.95	1.12	Medium clean
70	20	8	2	90	10	4.97	1.12	Medium clean
80	10	8	2	90	10	4.97	1.12	Medium clean
75	15	8	2	90	10	4.98	1.12	Medium clean
55	35	8	2	90	10	5.00	1.12	Medium clean
65	25	8	2	90	10	5.00	1.12	Medium clean
60	30	8	2	90	10	5.01	1.12	Medium clean
50	40	8	2	90	10	5.03	1.12	Medium clean
50	40	8	2	90	10	5.03	1.12	Medium clean
45	45	8	2	90	10	5.04	1.12	Medium clean
90	5	4	1	95	5	6.12	0.15	Very clean
95	0	4	1	95	5	6.12	0.15	Very clean
85	10	4	1	95	5	6.13	0.15	Very clean
80	15	4	1	95	5	6.15	0.15	Very clean
70	25	4	1	95	5	6.16	0.15	Very clean
75	20	4	1	95	5	6.16	0.15	Very clean
60	35	4	1	95	5	6.18	0.15	Very clean
65	30	4	1	95	5	6.18	0.15	Very clean
55	40	4	1	95	5	6.20	0.15	Very clean
50	45	4	1	95	5	6.21	0.15	Very clean
45	50	4	1	95	5	6.21	0.15	Very clean
50	45	4	1	95	5	6.21	0.15	Very clean
40	55	4	1	95	5	6.23	0.15	Very clean
100	0	0	0	100	0	8.22	0.00	Very clean

Note: Deteriorate is DO < 2 mg/L and BOD > 4 mg/L
Fairly clean is DO 2-4 mg/L and BOD 2-4 mg/L
Medium clean is DO 4-6 mg/L and BOD 1.5-2 mg/L
Very clean is DO > 6 mg/L and BOD < 1.5 mg/L

As shown in Table 5, results revealed that the suitable development plan in Trang watershed for very clean water quality was urban and industrial

land less than 5% or forest and agricultural land more than 95%. If urban and industrial land increase to 10% and forest and agricultural land decrease to 90%, the water quality would be medium clean. When urban and industrial land are more than 15%, water quality begin to fairly clean. Finally, water will be completely deteriorated if urban and industrial are more than 25% or forest and agricultural land are less than 75% as shown in Table 6. Consequently, the model developed by STELLA can be used to describe DO and BOD change over time and help in finding optimization of land allocation which does not disturb water quality in Trang watershed. For Further research, the model can be applied in other watersheds or

forecasting the environmental events as self-purification capability of river for solving river quality problem.

Table 6. The conclusion of suitable development plan in Trang watershed

%(Fo + Ag)	%(Ur + In)	Water Quality level
95	5	Very clean
90	10	Medium clean
85	15	Fairly clean
<75	>25	Deteriorated

4. Conclusions

The model was developed for describing the DO and BOD changes over time in Trang watershed

using STELLA program in four components of DO inflow, BOD inflow and DO and BOD outflows system. It had good agreement with the observed results. For finding optimization of land allocation for sustainable development without water pollution, it was found that if the percentage of urban and industrial land were less than 5% and also the percentage of forest and agricultural land were 95% the water quality would be very clean. If percentage of urban and industrial land increased to 10% and the percentage of forest and agricultural land was 90 %, the water quality in Trang watershed was still medium clean. If the percentage of urban and industrial land would be more than 15 % water quality would begin to fairly clean and if they were more than 25 % of total area and also the percentage of forest and agricultural land were less than 75 % of total area in watershed it would start to become the deteriorated water quality. Concerning water pollution for suitable development plan % of urban and industrial should not be over than 25% of total area, otherwise water quality would be deteriorated. Also, this indicating that STELLA program could simulate DO and BOD changes overtime in Trang watershed and other watershed. Therefore, STELLA program can be used as an appropriate tool for finding out suitable development plan with standard water quality.

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Bacterial Contamination of Microphones used in places of worship in Umuahia, Abia State, Nigeria

OSITA GABRIEL APPEH^{1*}, TOCHUKWU FRANK EGWUATU², ONWUBIKO
EMMANUEL NWANKWO¹ and ADURE CHRISTABEL IBE¹

¹Department of Microbiology, College of Natural Sciences, Michael Okpara University of Agriculture Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria

²Department of Cell Biology and Genetics, Faculty of Science, University of Lagos, Akoka-Yaba, Lagos, Nigeria.

Corresponding author e-mail: ositaappeh@yahoo.com

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Abstract

Bacteria can survive on the surface of the microscopic grooves and cracks and will go unnoticed, hence the presence of pathogenic bacteria on the user interface of microphone possesses a potential risk to vulnerable, immune compromised individuals. The aim of this study was to study the antibiotics patterns of bacteria isolated from microphones used at different churches in Umuahia, Abia State, Nigeria. 100 samples were collected from the mouthpiece and handles of the various microphones from 22 different churches in Umuahia with sterile swab sticks moistened with normal saline. A total of 85 isolates comprising of eight (8) genera were characterized from the samples. These organisms included *Staphylococcus* sp, *Coagulase negative Staphylococcus* (CoNS), *Streptococcus* sp, *Micrococcus* sp, *Bacillus* sp, *Proteus* sp, *Escherichia coli* and *Pseudomonas* sp. Frequency distribution of the isolates was as follows *Staphylococcus* sp. (5.88% of total), *Coagulase negative Staphylococcus* (CoNS) were (11.76%), *Streptococcus* sp. (9.41%), *Micrococcus* sp. (1.18%), *Bacillus* sp. (3.53%), *Proteus* sp. (17.65%), *Escherichia coli* (36.47%) and *Pseudomonas* sp. (14.12%). The sensitivity and resistance testing of the bacteria to different antibiotics showed that all the isolates were 100% sensitive to Peflaxacin, Ciprofloxacin and Gentamicin. The highest percentage resistance of 42.85% was recorded for Ampicillin while the least percentage resistant of 14.28% was recorded for Ofloxacin, Streptomycin and Cefalexin each. This study showed that microphones can aid in the spread of pathogenic microorganisms between individuals and among groups at large.

Keywords: Mouthpiece, Microphone, Antibiotics, Sensitivity, Resistance

1. Introduction

Bacteria can survive in the microscopic grooves and cracks on surfaces and will go unnoticed. Oils in the skin, dust, grime moisture and warmth from central heating systems provide an ideal environment for these bacteria to accumulate. Bacteria, such as *Escherichia coli*, can survive on dry air or sunlight (Ashgar and El-said, 2012). Bacteria that can cause severe gastroenteritis have been found on frequently touched surfaces. Majority (80%) of infection (Chandra *et al.*, 2014) are spread through hand contact with surfaces. Various Gram negative bacteria and Gram positive cocci were isolated from daily used gadgets like computer, microphones, mobile phones, stethoscopes etc. (Chandra *et al.*, 2014) computer keyboards, mice, elevator buttons and shopping carts (Al-Ghamdi *et al.*, 2011). Roxburgh (2005),

demonstrated that bacteria can be readily transferred from hands to almost any frequently used surfaces. Scientific research has shown that commonly used surfaces are potential sources of infectious bacteria leading to the spread of sickness and diarrhea (Reynolds *et al.*, 2005). Fomites such as Microphones carry germs and when one touches it and then touches the mouth, nose, eye etc., there may be transfer of germs in the body. The presence of pathogenic bacteria on the user interface of Microphone possesses a potential risk to vulnerable, immune compromised individuals. It has been shown that hard, nonporous surfaces have the highest bacteria transfer rates to hands (Rusin *et al.*, 2002). Microphones are commonly used in churches, schools, seminars, ceremonies and public gatherings. Bacterial contamination of microphones is a major health hazard and plays an important role

in the transmission of different diseases in public gatherings, schools and churches. The aim of this study was to study the antibiotics patterns of bacteria isolated from microphones used at different churches in Umuahia, Abia State, Nigeria.

1 Materials and Methods

Sample Collection

A total of 100 (≤ 5 microphones per centre) microphones were sampled at random from 22 places of worship within Umuahia, Abia State, Nigeria with the aid of sterile cotton swab sticks moistened with 0.85% normal saline before swabbing the mouthpiece and handle of the microphones. The cotton swab sticks were transferred into an ice-box and transported immediately to the laboratory for bacteriological analysis (Cheesbrough, 2006).

Bacterial Isolation

After sample collection, the specimens were transported to the Department of Microbiology Laboratory, Michael Okpara University, Umuahia, Nigeria where they were cultured using the streak plate method on MacConkey agar, 5% blood agar and nutrient agar respectively and incubated at 37°C for 24 hours (Cheesbrough, 2006).

Characterisation of Bacterial Isolates

The identification of bacteria from the surface of microphones was carried by standard methods. The isolates were identified by the modification of the methods described by Cheesbrough (2006), based on their morphological characteristics and biochemical tests. The isolates were examined for shape, elevation, opacity, size, edge and pigmentation. The following biochemical tests were carried out to identify and characterize the isolates: Gram staining, coagulase test, citrate

test, motility test, indole test, urease test, catalase test, triple sugar iron test and oxidase test.

Antibiotic Sensitivity Testing

Antibiotic disc sensitivity testing was performed on the identified isolates using disc diffusion method on Mueller-Hinton agar as described by Bauer *et al.*, (2009). In this method, standard paper discs impregnated with known amounts of antibiotics were placed on the Mueller-Hinton agar inoculated with the test organism and incubated at 37°C. The plates were incubated aerobically at 37°C for 24 h and the zones of inhibition developed were measured and recorded. The zones of inhibition (IZDs) of all the antibiotics in the discs measured and recorded were used to establish the antibiogram of the clinical isolates by comparing their IZDs with the IZD breakpoints already established by European Committee on Antimicrobial Susceptibility Testing (EUCAST, 2009). The isolates were classified as either resistance or intermediately sensitive or sensitive based on the guidelines of EUC AST, 2009. The antibiotics (Expert Diagnostics) used were Ofloxacin 10µg, Pefloxacin 10µg, Ciprofloxacin 10µg; Amoxicillin-Clavulanic acid 30µg, Gentamicin 10µg, Streptomycin 30µg, Cefalexin 10µg, Septrin 30µg and Ampicillin 30µg.

Data Analysis

Percent resistance/sensitive for each species of bacteria was calculated using SPSS version 23 and presented as simple percentages.

Results

Table 1 shows the source of the samples and the distribution of bacterial count according to the sample sources. In the table, churches L and M have the least number of microphone samples (2) and number of positive growth (1) while sample V has the highest number microphone sample (13) and the number of positive growth (10).

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Table 1: Source of Samples and Number of Samples

CHURCHES/FELLOWSHIPS	NUMBER SAMPLED (%)			NUMBER OF RECOVERED ISOLATES (%)		
	HANDLE (%)	MP (%)	TOTAL	HANDLE (%)	MP (%)	TOTAL
A	3 (50)	3(50)	6	1(33.33)	2(66.67)	3
B	2(50)	2(50)	4	2(100)	1(50)	3
C	2(40)	3(60)	5	2(100)	2(66.67)	4
D	2(66.67)	1(33.33)	3	1(50)	1(100)	2
E	1(33.33)	2(66.67)	3	1(100)	2(100)	3
F	2(50)	2(50)	4	2(100)	2(100)	4
G	4(57.14)	3(42.86)	7	4(100)	3(100)	7
H	3(60)	2(40)	5	3(100)	2(100)	5
I	1(33.33)	2(66.67)	3	1(100)	2(100)	3
L	2(66.67)	1(33.33)	3	2(100)	1(100)	3
K	1(33.33)	2(66.67)	3	1(100)	2(100)	3
	—	2(100)	2	—	1(50)	1
M	1(50)	1(50)	2	—	1(100)	1
N	2(50)	2(50)	4	1(50)	2(100)	3
O	3(75)	1(25)	4	2(66.67)	1(100)	3
P	2(33.33)	4(66.67)	6	2(100)	4(100)	6
Q	4(66.67)	2(33.33)	6	3(75)	2(100)	5
R	2(50)	2(50)	4	2(100)	2(100)	4
S	1(33.33)	2(66.67)	3	1(100)	1(50)	2
T	2(33.33)	4(66.67)	6	2(100)	4(100)	6
U	2(50)	2(50)	4	2(100)	2(100)	4
	8(61.54)	5(38.46)	13	5(62.5)	5(100)	10
			100	85		

KEY: MP = Mouthpiece

Morphological characteristics and biochemical identification of the bacterial isolates are shown in table 2 and 3 respectively, which indicate the recovery of 85 isolates comprising of 8 genera of bacteria namely *Staphylococcus aureus*, *Micrococcus* sp, *Streptococcus* sp, *Bacillus* sp, *Proteus* sp, *Escherichia coli*, *Pseudomonas aeruginosa* and coagulase negative *Staphylococcus*.

Table 2: Morphological characteristics of bacteria isolates

ELEVATION	SHAPE	OPACITY	SIZE	EDGE	PIGMENTATION	ISOLATES
Convex	Circular	Opaque	Medium	Entire	Golden yellow	<i>Staphylococcus aureus</i>
Umbonate	Oval	Transparent	Medium	Undulate	Green	<i>Pseudomonas aeruginosa</i>
Raised	Circular	Opaque	Small	Entire	Haemolytic on blood agar	<i>Streptococcus</i> sp.
Raised	Circular	Translucent	Small	Entire	Pink on MacConkey	<i>Escherichia coli</i>
Convex	Circular	Translucent	Small	Entire	White	Coagulase negative <i>Staphylococcus</i>
Convex	Circular	Opaque	Small	Entire	Non diffusible Bright yellow	<i>Micrococcus</i> sp.
Convex	Circular	Transparent	Small	Entire	Yellow	<i>Proteus</i> sp.
Umbonate	Irregular	Opaque	Large	Undulate	White	<i>Bacillus</i> sp.

Table 3: Biochemical identification of the isolates

	GRAM	REACTION CATALASE	COAGULASE	TSI	MOTILITY	INDOLE	UREASE	CITRATE	OXIDASE	PROBABLE ORGANISMS
Cocci	+	+	+	-	-	-	-	-	-	<i>Staphylococcus aureus</i>
Rod	-	+	-	-	+	-	+	+	+	<i>Pseudomonas aeruginosa</i>
Cocci	+	-	-	-	-	-	-	-	-	<i>Streptococcus sp</i>
Rod	-	+	-	+	+	+	-	-	-	<i>Escherichia coli</i>
Cocci	+	+	-	-	-	-	-	-	-	CoaN. <i>Staphylococcus</i>
Rod	+	+	-	-	+	-	-	+	+	<i>Bacillus sp</i>
Rod	-	+	-	-	+	+	+	+	-	<i>Proteus sp</i>
Cocci	+	+	-	-	-	-	-	-	+	<i>Micrococcus sp</i>

KEYWORDS

+ = Positive

- = Negative

CoaN = Coagulase Negative

Results for the percentage of occurrence of different bacteria isolate are represented in table 4 which show that *Escherichia coli* has the highest percentage of occurrence (36.47%) followed by *Proteus* with (17.65%) and *Micrococcus* has the lowest percentage of occurrence with (1.18%).

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Table 4: Percentage of occurrence of different isolates

			<i>Escherichia coli</i>	31	36.47
			<i>Pseudomonas aeruginosa</i>	12	14.12
			Total	85	100
<i>Staphylococcus aureus</i>	5	5.88			
Coagulase negative <i>Staphylococcus</i>	10	11.76			
<i>Streptococcus sp</i>	8	9.41			
<i>Micrococcus sp</i>	1	1.18			
<i>Bacillus sp</i>	3	3.53			
<i>Proteus sp</i>	15	17.65			

Antibiotic susceptibility pattern result is showed in table 5. *S. aureus* has the highest susceptibility to streptomycin (100%) and *Micrococcus* is completely resistant to streptomycin (0%). *E. coli* has the highest susceptibility to Tarivid (80.7%) and *Micrococcus* is resistant (0%). *Micrococcus* has the highest susceptibility to Peflacin (100%) and *Staphylococcus aureus* has the least susceptibility (20%).

Table 5: Antibiotic sensitivity pattern of isolates

ISOLATES	NUMBER TESTED	NUMBER SENSITIVE (%)								
		OFX	PEF	CPX	AU	S	CEP	SXT	PN	CN
<i>Staphylococcus aureus</i>	5	2(40)	1(20)	4(80)	2(40)	5(100)	3(60)	0(0)	1(20)	3(60)
<i>CoaN. Staphylococcus</i>	10	8(80)	9(90)	8(80)	5(50)	8(80)	5(50)	2(20)	7(70)	8(80)
<i>Streptococcus sp.</i>	8	2(25)	3(37.5)	4(50)	2(25)	6(75)	4(50)	2(25)	2(25)	5(62.5)
<i>Micrococcus sp.</i>	1	0(0)	1(100)	1(100)	0(0)	0(0)	1(100)	1(100)	0(0)	1(100)
<i>Bacillus sp.</i>	3	—	—	—	—	—	—	—	—	—
<i>Proteus sp.</i>	15	12(80)	13(86.67)	12(80)	6(40)	12(80)	6(40)	4(26.67)	0(0)	13(86.67)
<i>Escherichia coli</i>	31	25(80.7)	20(64.5)	20(64.5)	10(32.3)	26(83)	8(25.8)	3(9.7)	5(16.1)	25(80.7)
<i>Pseudomonas aeruginosa</i>	12	6(50)	5(54.16)	4(33.33)	0(0)	7(58.33)	0(0)	0(0)	0(0)	7(58.33)

OFX – Tarivid (10µg) S– Streptomycin (30µg) SXT–Septrin (30µg) CN– Gentamicin (10µg)
 PEF– Peflacin (10µg) CEP– Ceporex (10µg) PN–Ampicillin (30µg) CPX–Ciprofloxacin (10µg)
 AU–Augmentin (30µg)

Discussion

Microphones are of the most commonly touched surfaces today. In this study, the microphones examined were contaminated with a considerable number of Gram positive and Gram negative bacteria and this is in agreement with the research findings of Adamu *et al.*, (2012) and Catano *et al.*, (2012) who obtained Gram positive and Gram negative bacteria from surfaces from currency banknote and computer keyboards, curtains, cell phones, white coats and ties respectively. Findings from this study revealed *Escherichia coli* to be the most frequently occurring isolate with the percentage occurrence of 36.47%. This was found to be at variance to the findings of Oluduro *et al.*, 2011 who reported *Staphylococcus aureus* (35.8%) as the frequent bacteria contaminant of electronic hardware in Ile-Ife. *Escherichia coli* is a normal flora of the gastrointestinal tract which can be picked up easily from toilet door handles. In a society of low hygiene, this probably explains its preponderance as a bacterial contaminant of surfaces. *Escherichia coli* has also been associated with various infectious disease conditions and nosocomial infections. Since users constantly touch interfaces, there is every chance of introducing *Escherichia coli* onto the interface in use.

Bacillus sp. were isolated from the findings in this research, and their presence could be explained by the fact that *Bacillus* sp. are ubiquitous in nature with their spores able to resist environmental changes, withstand dry heat and certain chemical disinfectants for moderate period. This finding is in agreement with the research carried out by Datta *et al.*, (2009) who reported that large number of *Bacillus* spp was transferred from fingertips or hands touching inanimate surfaces.

Staphylococcus aureus that was isolated from the samples is a major component of the normal flora of the skin and nostrils. This probably explains its high prevalence as a contaminant, as it can be easily discharged by several human activities including sneezing, talking, and contact with moist skin (Itah and Ben, 2004). It has also been associated with numerous infectious disease conditions and nosocomial infections. It follows that since users constantly touch interface and often sneeze, there is every chance of introducing

Staphylococcus aureus on to the interface in use. Also, airborne organisms can be transported from users to passerby. The isolation of *Micrococcus* sp. from this study was in conformity with the work of Opera *et al.*, (2013) and Bashir *et al.*, (2016) who reported the isolation of *Micrococcus* sp. from public toilet.

Conclusion

The findings of this study showed that microphones can aid in the spread of microorganisms between individuals and among groups at large. Pathogenic bacteria isolated from microphones in this study indicate that they can be vehicles for disease transmission. Microbes present on the mouthpiece and handle of a microphone can aid in the transfer of germs to the body and also cause infections. Cleaning and disinfection of hands and microphones (mouthpiece and handle) will help in the removal and interruption of the growth of these pathogenic organisms thus reducing the rate of disease transmission and contamination.

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Description Logics for Fishery Time

Le Thi Bao Ngoc *

¹Faculty of Science and Technology, Kien Giang College of Education, Vietnam

Corresponding author E-mail: *baongoc506@gmail.com

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Abstract

Controlling time in fisheries is executed by analyzing data which are picked up from investigated documents to make significant decisions. When data are big enough, time information of objects definitely become hard to represent to get knowledge quickly and temporal relationships have gone more difficult for observing. This article concentrate on introducing Description Logics (DLs) which is extended by rules as an appropriate knowledge representation formalism for managing fishery time. A DL knowledge base for fisheries is installed with relations between areas and creatures, creatures and catchers, catchers and time for catching, time and opened areas, catchers and tools. To build this model, we use Protégé for illustrating an ontology of fisheries through data got from the document of Vietnamese mangrove fisheries. This document is published by Agriculture Institute of Vietnam in 2015 with statistics in detail. The research shows the way to represent fishery time by DLs.

Keywords: Description logics, Temporal fishery representation, DLs for time.

1. Introduction

Marine resources have significant biological productivity, especially value of creatures. With roles of making and growing creatures, sea has been providing the great amount of annual economic value of creatures and bringing the high power of economy for communities living by fishing.

To protect marine products, fisheries need to be managed seriously. For Kevern and Serge (2009), some of base solutions for managing fisheries showed are:

- Regulating time for opening areas and periods for each vessel in catching.
- Regulating the quantities of creatures caught in each area.
- Claiming restrictions about size of fishing tools for vessels, small crafts and fishers.

Therefore, the process of the fishery management is going to be based on some essential elements and relationships of them in order to guard diversity of species as well as sustainable productivity for fishermen. The elements in the fishery model are species, fishing tool, catcher, fishing area, time and different levels of interaction between them. However, the management always has a lot of challenges which come from complex interaction of elements in the fisheries and diversity of these elements.

The following partial list sketches some of issues with respect to each element:

- Species: All creatures have economic valuation in sea.
- Fishing tool: Some of methods mainly used in

fisheries.

- Time: Periods are suitable in fishing and protecting resources simultaneously.
- Fishing area: These areas are locations having zones for living of sea creatures.
- Catcher: Objects operate fishing gears.

Besides issues from interaction of elements and representing information, interaction of time and its representation in fisheries have also the significant part.

The article approaches DLs to describe time and its interaction in fisheries. Protégé software can be seen as a tool to transform this model into the fishery ontology for illustrating.

We arrange the article as the following structure: Description logics (section 2) are represented before knowledge base of fisheries (section 3). The next section is experiments for time fisheries in protégé (section 4) and conclusions for the last section (section 5).

2. Description logics

2.1. Overview

DLs is one of the latest terminology in a family of knowledge representation. Before a couple of words “description logics” becomes popular, it is said as phrases “knowledge representation languages” or “concept languages” (Franz et al, 2002; Franz et al, 2007).

DLs can be used to represent the conceptual knowledge of an application domain in a structured and formally well-understand way by classification of concepts and individuals. The result from

classification of concepts is subconcept/superconcept relationships (called subsumption relationships) between the concepts of a given terminology as well as acknowledgment for structuring the terminology in the form of a subsumption hierarchy. This hierarchy provides valuable information about connections of different concepts and it is able to speech up other inference services. Determining whether this instance relationship is implied by the description on the individual and the definition of the concept is the other result from classification of individuals. Furthermore, instance realationships may trigger the application of rules that insert additional facts into the knowledge base.

2.2. Knowledge bases

Knowledge representation systems based on DLs provide tools for creating knowledge bases, reasoning their contents and running them.

A DL knowledge base usually consists of two parts. The terminological part (TBox), which defines concepts and also states additional constraints on the interpretation of these concepts, and the assertional part (ABox), which describes individuals and their relationships to each other and to concepts. In addition, through reasoning services we can get right knowledge. Besides storing terminologies and assertions, DL systems also offer services that reason about them such as reasoning tasks to determine whether a description is satisfiable or whether one description is more general than another one.

2.3. Description languages

Complex concepts in DLs are built by AL (attributive language) or extend languages of AL called description languages from the family of AL-languages (Franz et al, 2002; Franz et al, 2007). Besides, there are also many languages from family of calculus with different expressive power (SHIO, SHION...) (Yu, 2008). Starting with description bases and rules for building concepts, description languages help to make new concepts in knowledge based systems.

2.3.1. Basic description language AL

$C, D \rightarrow A$	(atomic concept)
\top	(universal concept)
\perp	(bottom concept)
$\neg A$	(atomic negation)
$C \sqcap D$	(intersection)
$\forall R. C$	(value restriction)
$\exists R. T$	(limited existential quantification)

Table 1. The syntax rule of attributive language

Basic elements of the AL are concepts and roles of axomic concepts. Complex descriptions are

formed by associations of the elements through constructors. In abstract notation, the letters A and

B are used for atomic concepts, the letter R for atomic roles, and the letter C and D for concept descriptions. Concept descriptions in AL are formed according to the following syntax rules in Table 1. (Franz et al, 2002).

2.3.2. The family of AL languages

The Figure 1 lists some elements of the family AL-languages (Yu, 2008). ALC is a combination between three letters in which the letters AL stand for attributive language and the letter C for complement. Besides ALC, other letters indicate various DL extensions including the following:

- I for inverse roles.
- F for functional restrictions.
- H for role hierarchy
- Q for qualified number restrictions

Description Languages Name	Propositional constructs			Universal/ Existential Restriction	Functional Restriction	Qualified Number Restriction	Role Hierarchy	Inverse Role	Transitive Role	Nominal
	\sqcap	\sqcup	\neg	$\forall R. C$ $\exists R. C$	$\exists \leq 1 R$ $\exists \geq 1 R$	$\exists \leq n R. C$ $\exists \geq n R. C$	$R_1 \sqsubseteq R_2$	R^-	S	$\{o\}$
ALC	✓			✓						
ALCI	✓			✓				✓		
ALCFI	✓			✓	✓			✓		✓
ALCHI	✓			✓		✓	✓	✓		

Figure 1. Some language elements of the family AL-languages

3. The fishery knowledge base

In this section, a knowledge base for fisheries is launched with DLs. Foundations of fisheries are represented in the TBox T. The ABox A attaches information about fishing activities in Vietnamese mangrove forests from the documentary about fisheries (Nguyen et al, 2015). It is later enhanced by new assertion obtained through ABox inference. The description of the rule base R for inferring will be shown here.

3.1 TBox

The fishery knowledge base which is a collection of definitions of concepts of fisheries, their relations and inclusion relations between the concepts. Those concepts are creature, tool, area, catcher and time. Basically, marine creatures consists of fish, crustacean and mollusc (Nguyen et al, 2015). Crustacean has three groups being crab, shrimp and prawn (Marine Education Society of Australasia, 2015) as a number of mollusc groups namely shellfish, snail and squid (Malaysia Biodiversity Information System, 2015).

Hierarchy All axiom concepts are arranged in different levels of a specialization structure is called a hierarchy. A hierarchy of fisheries is illustrated as a diagram in Figure 2(a). Each group of creatures contains another lower level of its as representative information.

Inclusions are described on the following way. For example, “All fish is creatures”

$$\text{Fish} \sqsubseteq \text{Creature}$$

A concept is equivalent to composition of other concepts below it in the hierarchy is represented through sufficient conditions for being that concept.

The description of “A fauna consists of fish, shrimp, squid, sea snail, shellfish and crab” is:

$$\text{Fauna} \equiv \text{Crustacean} \sqcup \text{Fish} \sqcup \text{Mollusc}$$

Disjoints between subconcepts can be clearly expressed. “Mollusc is disjoint with Fish and Crustacean”

$$\text{Mollusc} \equiv \neg \text{Fish} \sqcap \neg \text{Crustacean}$$

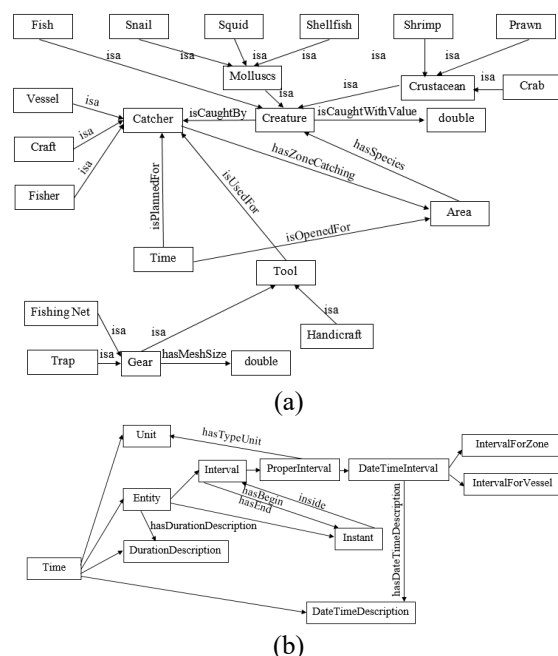


Figure 2. Fisheries TBox; (a) Hierarchy, (b) Subsumption hierarchy

Time representation Time is the indefinite continued progress of existence and events in the past, present, and future regarded as a whole. Time is formed by instants and intervals while intervals are periods between beginning instants and ending instants. There are many instants being inside an interval. Normally, intervals have positive values, the zero value is specify for two instants overlapping each other. In this research, only positive time intervals are considered as figure 2(b). Besides, each time period has to have units itself.

Description of duration is used for representing intervals with time arguments in annual fishing cycle. For example, an interval may

have duration as 2 days, or 1 day and 10 hours, or 1 month.

Description of date time is used for specifying exact time to intervals that have positive time length through its subconcepts (12 months).

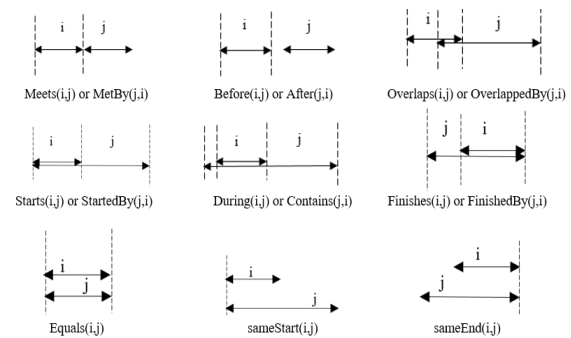


Figure 3. Relationships between of intervals

Relations between intervals can be seen in figure 3. Their relative orientations are illustrated on the time line with two intervals namely i and j . A description of the arrangement of an temporal individual with respect to another comprises ABox role, assertions.

Restrictions By using concepts and time roles, restrictions are formulated on the set of possible models. The restrictions are divided into two groups: time restrictions and fishery building regulations. First, the time restrictions are written in DLs as follows:

“An interval has starting and ending instants”

$$\text{Interval} \sqsubseteq \exists \text{hasEnd. Instant} \sqcap \exists \text{hasBegin. Instant}$$

“All instants are inside intervals”

$$\text{Instant} \sqsubseteq \forall \text{inSide. Interval}$$

“Each entity has a description about duration with time arguments”

$$\text{Entity} \sqsubseteq \exists \text{hasDurationDescription. DurationDescription}$$

“Each date time interval has a description about its date time”

$$\text{DateTimeInterval} \sqsubseteq \exists \text{hasDateTimeDescription. DateTimeDescription}$$

“Every proper intervals at least one unit”

$$\text{ProperInterval} \sqsubseteq \exists \text{hasTypeUnit. Unit}$$

Second, the fishery building regulations represented are:

“Total of time periods for catching of each vessel is greater than 1 and less than 4”

TotalForVessel $\sqsubseteq \exists_{\geq 1}(\text{Starts.IntervalForVessel}$

$\sqcap \exists_{\leq 4}\text{Starts.IntervalForVessel}$

or

TotalForVessel \sqsubseteq

$\exists_{\geq 1}(\text{Finishes.IntervalForVessel}$

$\sqcap \exists_{\leq 4}\text{Finishes.IntervalForVessel}$

“Time periods for vessels are during time of zones”

IntervalForVessel $\sqsubseteq \forall \text{During.IntervalForZone}$

“Intervals for vessels do not overlap, are not before and not after intervals for zones”

IntervalForVessel \sqsubseteq

$\neg \text{Overlap.IntervalForZone} \sqcap$

$\neg \text{Before.IntervalForZone} \sqcap$

$\neg \text{After.IntervalForZone}$

“Starting interval of a zone is the same as or before one of starting interval of vessels”

SIntervalForZone \sqsubseteq

$\exists \text{sameStart.SIntervalForVessel} \sqcup$

$\exists \text{Before.SIntervalForVessel}$

“Ending interval of a zone is the same as or after one of ending interval of vessels”

EIntervalOfZone \sqsubseteq

$\exists \text{sameEnd.EIntervalOfVessel} \sqcup$

$\exists \text{After.EIntervalOfVessel}$

Besides managing fisheries involves many restrictions, regulating the quantity of fish caught is one of the restrictions for insuring sustainable and responsible fisheries. Regulating type of gear and its size as well as specifying closed seasons and closed areas is incredibly important restrictions to protect sustainable utilization of the resources.

3.2. ABox

A delegate chosen from the statistic document published about the fisheries at Vietnamese (Nguyen et al, 2015) to illustrate ABox is the information of *Metapenaeus Affinis*, a type of prawn caught at Hung Hoa, an area of mangroves in Vietnam. Temporal individuals are supposed optional inputs and their relationships are built to support for inferring through rules.

In Hung Hoa, *Metapenaeus Affinis* is caught by vessels and crafts having gears (gill-net, drift-net, weir and cage) at Hoa Lam and Phong Dang with opened time from Febuary until June and from October to November, respectively. (Nguyen et al, 2015). The opened time of Hoa Lam and Phong Dang is intervals, namely interval_{0206} and interval_{1010} . Supposing Vessel1, Vessel2, Vessel3

and Vessel4 caught at Hoa Lam. Vessel1 caught 5.4 kg in interval_{0203} , Vessel2 caught in interval_{0305} , Vessel3 caught in interval_{0405} and Vessel4 caught in interval_{0406} . From these details, a small part of ABox is:

$A = \{$ *Metapenaeus affinis* : prawn,
 HungHoa : area,
 Vessel1, Vessel2, Vessel3 : vessel,
 HoaLam, PhongDang : zone,
 (*Metapenaeus affinis*, HungHoa):
isSpeciesOf,
 (HungHoa, HoaLam) : hasPart,
 (interval_{0206} , HoaLam) : isOpenedFor,
 (interval_{0203} , Vessel1) : isPlannedFor,
 (interval_{0206} , interval_{1011}) : before,
 (interval_{0203} , interval_{0405}) : meet,
 (interval_{0203} , interval_{0304}) : overlap,
 (interval_{0304} , interval_{0205}) : during,
 (interval_{0103} , interval_{0304}) : start,
 (interval_{3004} , interval_{0304}) : finish,
 ...}

“*Metapenaeus affinis* in Hung Hoa is caught at HoaLam and PhongDang”

MetapenaeusAffinisInHungHoa: isSpeciesOf.
(HoaLam \sqcup PhongDang)

“Vessel1 catches 5.4 kg for *Metapenaeus Affinis* at HoaLam”

Vessel1: caught. *MetapenaeusAffinis*

$\sqcap = 5.4$ isCaughtWithValue

\sqcap hasZoneCatching. HoaLam

“ Interval_{0203} for Vessel1 overlaps interval_{0304} for Vessel2”.

$\text{Interval}_{0203} \sqsubseteq \text{Overlaps.Interval}_{0305}$

“ Interval_{0203} for Vessel1 is before interval_{0405} for Vessel3 ”

$\text{Interval}_{0203} \sqsubseteq \text{Meets.Interval}_{0405}$

3.3. Rules

From the time relationships represented, temporal rules can be created to serve for managing fisheries:

“If an interval x_3 meets intervals x_1 and x_2 , represented with relationship sameStart(x_1, x_2)”

(x_1, x_2) : sameStart \leftarrow

(x_3, x_1) : Meets $\wedge (x_3, x_2)$: Meets $\wedge x_1$: Interval
 $\wedge x_2$: Interval $\wedge x_3$: Interval

“If an interval x_3 before an interval x_1 and the interval x_1 is before an interval x_2 . So the interval x_3 is before the interval x_2 and represented with relationship Before(x_3, x_2)”

(x_3, x_2) : Before \leftarrow

(x_3, x_1) : Before $\wedge (x_1, x_2)$: Before $\wedge x_1$: Interval
 $\wedge x_2$: Interval $\wedge x_3$: Interval

“If an interval x_1 has finishing interval k , x_1 is during an interval x_2 , x_1 and x_2 have the same ending interval. Therefore, x_2 has also fishing interval k , represented with relationship $Finishes(k, x_2)$ ”

$(k, x_2): Finishes \leftarrow$
 $(k, x_1): Finishes \wedge (x_1, x_2): During$
 $\wedge (x_1, x_2): sameEnd \wedge x_1: Interval \wedge x_2: Interval$
 $\wedge k: Interval$

Some other rules for fishing can also be showed below:

“If a species lives in an area, this species certainly lives in the superconcept of the area”

$(x_1, x_3): hasSpecies \leftarrow$
 $x_1: Area \wedge x_2: Area \wedge x_3: Creature$

“If x_1 is one of the following elements: Fishing net (drag-net, gill-net); trap (cage, drift-net, weir); handicraft (spear, harpoon), x_1 becomes a fishing tool.”

$x_1: Trap \vee x_1: Handicraft$

can be rewrited is:

$x_1: Tool \leftarrow$
 $x_1: fishingNet \vee x_1: Trap \vee x_1: Handicraft$

“The species which is crab is also Crustacean” is:
 $hasPart(?z, ?y) \leftarrow x: Crab \wedge y: Creature \wedge$
 $z: Crustacean \wedge hasPart(?z, ?x) \wedge$
 $hasPart(?x, ?y)$

4. Experiments

In this section, we use Protégé version 4.3 - a free, open source platform to represent the knowledge base that are described above. Information about fisheries in Vietnam (Nguyen et al, 2015) are the background to build an ontology of fisheries. After that, temporal rules are built to infer relationships of relevant interval and instant elements.

Example 1. If interval i meets interval j , then j and k have the same starting interval, represented with relationship $Meets(i, k)$.

Rule statement:

$Meets(?i, ?j), sameStart(?j, ?k) \rightarrow Meets(?i, ?k)$

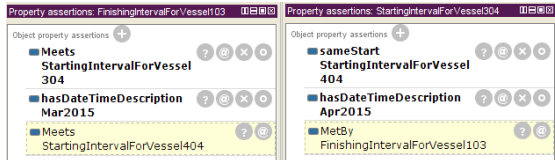


Figure 4. Result for example 1

Example 2. If an interval i meets interval k and overlaps interval j , then interval j and interval k have the same ending interval, $During(k, j)$ is the

relationship for representation.

Rule statement:

$Meets(?i, ?k), Overlaps(?i, ?j), sameEnd(?j, ?k)$
 $\rightarrow During(?k, ?j)$

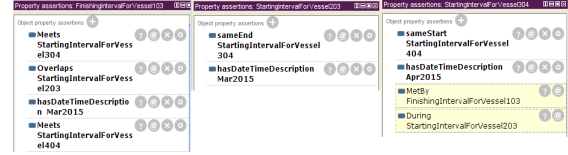


Figure 5. Result for example 3

Example 4. If interval i and j have the same starting interval, intervals i and j have all the same durations with units (month, week, day) respectively, $sameEnd(?j, ?i)$ is represented for this relationship.

Rule statement:

$hasUnitType(?i, unitMonth), hasUnitType(?i, unitWeek), hasUnitType(?j, unitDay),$
 $hasUnitType(?j, unitMonth), hasUnitType(?j, unitWeek), sameStart(?i, ?j), days(?i, ?l), days(?j, ?l),$
 $months(?i, ?m), months(?j, ?m), weeks(?i, ?k), weeks(?j, ?k) \rightarrow sameEnd(?j, ?i)$

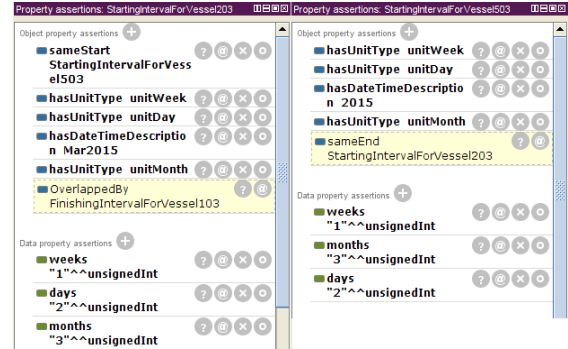


Figure 6. Result for example 4

5. Conclusions

In this research, we proposed an approach to DLs for time in fisheries. This model describes relationships between of two temporal objects. From here, there are many relationships between other temporal objects can be reasoned by rules. After denoting the fishery knowledge base into Protégé for experiments, we get some favorable results about reasonings for temporal relationships. We believe this contribution can be solve problems about representing temporal objects and relationships between of them in fisheries.

6. Acknowledgements

The researchers would like to thank Kien Giang library for supporting materials relating to the study area.

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Application of Principal Component Analysis As A Data Reducing Technique

Fayose Taiwo Stephen¹, Egobi Mary Ekundayo², Adebara Lanre³,

^{1,3}Department of Mathematics and Statistics, The Federal Polytechnic,
Ado Ekiti, Ekiti State, Nigeria

²Department of Statistics, Federal University of Technology,
Akure, Ondo State, Nigeria

Corresponding author e-mail: fayose_ts@fedpolyado.edu.com

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Abstract

This paper is on the application of principal component as a data reducing technique on economic variables for the period of 26 years. The source of data was secondary and was collected from the Central Bank of Nigeria Statistical Bulletin. The aim is to use principal component analysis effectively and profitably to reduce the large and massive economic variables (Data) to a smaller number of PCs while retaining as much as possible of the variation in the original variables. The methodology employed Principal Component which are orthogonal in nature from the original Economic Variables. The criterion for selecting the number of Principal Component to be extracted is the KAISER'S CRITERION which was suggested by GUTTMAN and adopted by KAISER. The result of the analysis revealed that the variables BOP, LR, and INFL have low correlation coefficient with other variables. Furthermore, results showed that the large sample size of economic variables have being reduced and the principal components are extracted in which the first Principal Component have the highest number of variables which are positively highly correlated, the second Principal Component loads positively with Crude Oil production, Lending Rate and Inflation Rate while the third Principal Component load positively with Balance of Payment.

Keywords: Principal Component Analysis, Principal Component, Kaiser's Criterion, Guttman, Kaiser, Karhunen-Loeve Transform, Proper Orthogonal Decomposition

1. Introduction

Principal Component Analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to (i.e., uncorrelated with) the preceding components. Principal components are guaranteed to be independent only if the data set is jointly normally distributed, PCA is sensitive to the relative scaling of the original variables. Depending on the field of application, it is also named the discrete **Karhunen-Loeve Transform (KLT)**, the

Hotelling Transform or Proper Orthogonal Decomposition (POD).

PCA was invented in 1901 by Karl Pearson. The technique has found application in many diverse fields such as Ecology, Economics, Psychology, Meteorology, Oceanography and Zoology. Now it is mostly used as a tool in exploratory data analysis and for making predictive models that is, to assist in the data analysis, PCA (among other techniques) is generally employed as both a descriptive and data reduction technique.

In the development of PCA, Pearson was interested in constructing a line or a plane that "best fits" a system of points in q -dimension space. Statistically speaking, PCA represents a transformation of a set of q correlated variables into linear combinations of a set of q pair-wise uncorrelated variables called Principal Components. Components are constructed so that the first component explains the

largest amount of total variance in the data and each subsequent component is constructed so as to explain the largest amount of the remaining variance while remaining uncorrelated with (orthogonal to) previously constructed components.

We define the dimension of the data set to be equal to the number of principal component. The set of q principal components is often reduced to a set of size K , where $1 \leq k$ for all q . The objective of dimension reduction is to make analysis and interpretation easier while at the same time retaining most of the information (variation) contained in the data. Clearly, the closer the value of K is to q the better the PCA model will fit the data since more information has been retained, while the closer K is to 1, the simpler the model.

Many methods have been proposed to determine the number K , that is, the number of “meaningful” components. Some methods can be easily computed while others are computationally intensive. Methods include (among others): the broken stick model, the Kaiser-Guttman test, Log-Eigen value (LEV) diagram, Velicer’s Partial Correlation procedure, Cattell’s Scree test, Cross-validation, bootstrapping techniques cumulative percentage of total variance, and Bartlett’s test for equality of eigen values.

Data reduction is frequently instrumental in revealing mathematical structure. Karr and Martin note that the percent variance attributed to Principal Components derived from real data may not be substantially greater than that derived from randomly generated data. The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores (the transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardized original variable should be multiplied to get the component score). PCA is the simplest of the true eigenvector-based multivariate analyses. Often, its operation can be thought of as revealing the internal structure of the data in a way that best explains the variance in the data.

1.1 Statement of the Problem

In this study, our emphasis is on the application of principal component as a data reducing technique on economic variables for the period of 26 years (1980-2005) by correlating GDP, External Reserve,

Exchange Rate, External Debt, Inflation Rate, Lending Rate, Money Supply, Crude Oil Production, Balance of payment, Balance of Trade and Oil Revenue as our selected Economic variables.

We shall seek solutions to the following problems;

- Could the large number of measurement be replaced by a small number of measurement (functions) of them without the loss of information?
- How many components do we extract to avoid loss of information?

1.2 Aim and Objectives of the Study

The aim of this study is to use principal component analysis effectively and profitably to reduce the large and massive economic variables (Data) to a smaller number of PCs while retaining as much as possible of the variation in the original variables. The objectives are:

- To summarize patterns of correlations among observed variables;
- To determine the number of components to be extracted;
- To discover or to reduce the dimensionality of the data set;
- To identify new meaningful underlying variables.

1.3 Materials and Methods

The method of PCA was used to form a new set of variables called the Principal Component which are orthogonal in nature from the original Economic Variables. The criterion for selecting the number of Principal Component to be extracted is the KAISER’S CRITERION which was suggested by GUTTMAN and adopted by KAISER. The criterion states that only Principal Component(s) having Latent root (Eigen value) greater than one are retained in the analysis. That is, we retain P_i iff $\lambda_i > 1$ CHI-SQUARE TEST.

1.4 Method of Data Collection

The method used is transcription from records. The data for this study were collected from the Central Bank of Nigeria (CBN) Statistical Bulletin (Golden Jubilee Edition, 2008). The data were collected for the period of 1980-2005.

Having mentioned the method for collecting the required data and the period, it becomes necessary to state the method for which the data was analyzed. The correlation matrix of the variables was estimated using SPSS version 17.0. An iterative procedure of the Principal Component Analysis was employed in order to obtain the Eigen Values to be extracted (λ_i), the normalized characteristic vectors (V_i), the Principal Components and the values for each Component extracted (P 's) using an initial guessed vector (X_0).

1.5 Findings

- The choice of the initial guessed vector of $(1,1,1,1,1,1,1,1,1)^T$ was utilized in all of the iterations without alternating them.
- We discovered that the variables BOP, LR, and INFL have low correlation coefficient with other variables.
- As the extraction continues, higher powers of R are required for the system to converge and at the point in which the principal components were obtained based on KAISER'S CRITERION the power of R began to reduce for the system to converge.
- Our major findings was that the large sample size of economic variables have been reduced and the principal component are extracted in which the first Principal Component have the highest number of variables which are positively highly correlated, the second Principal Component loads positively with Crude Oil production, Lending Rate and Inflation Rate while the third Principal Component load positively with Balance of Payment.

1.6 Conclusion

Principal Component Analysis is a tool imperative as far as data reduction is concerned. It is very helpful in determining empirically how many dimensions or underlying construct accounts for most of the variance. From the analysis, we may infer that with the aid of Principal Component Analysis the researchers have been able to project the large variables (ten predictor variables) into three Principal Components called the factors and the Principal Component were found to be a linear combination of the original variables.

The variables that were linearly combined for each of the Principal Component were obtained based on their correlation with the Principal Components. Knowing fully well that there are several other analysis that can be used as a data reducing technique on economic variables, the method of principal component yielded reliable results.

1.7 Recommendation

The followings are suggested as possible recommendation for further study:

- Future study should employ more or less observations with proper model specification and estimation.
- The Screen Test should also be employed as a criterion for selecting PC since there may be some λ which by approximation will be unity (by Kaiser's criterion).
- We recommend that the size of explanatory variables for this study period should be increased.

1.8 Acknowledgement

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Thai Herb Identification with Medicinal Properties Using Convolutional Neural Network

Lawankorn Mookdarsanit^{1*}, Pakpoom Mookdarsanit²

^{1*}Business Computer Department, Faculty of Management Science, Chandrakasem Rajabhat University

²Computer Science Department, Faculty of Science, Chandrakasem Rajabhat University

^{1*,2}39/1 Ratchadaphisek Rd, Khwaeng Chandrakasem, Khet Chatuchak, Bangkok 10900, Thailand

Corresponding author e-mail: *lawankorn.s@chandra.ac.th

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Abstract

This paper builds an intelligent computer model to identify Thai herb from a single image using convolutional neural network. Since Thailand is one of the world herbal source. We used 2,700 herbal images with their medicinal properties to train the computer model that covered 11 well-known Thai herbs: Siamese Rough-bush, Cumin, Holy Basil, Sweet Basil, Cha Muang, Kaffir-lime Leaf, Siamese Morning-glory, Pandanus Leaf, Mint, Chinese Kale and Chaplu, respectively. The feature extraction framework and model architecture were done by Fast Region Convolution Neural Network (Fast R-CNN) and Visual Geometry Group Network (VGGNet) that produce the recall as higher than 0.75 and the precision as higher than 0.80.

Keywords: Herb Identification, Leaf Recognition, Convolutional Neural Network, VGGNet, Fast R-CNN

1. Introduction

Thai medicinal herbs or herbal medicines refer to some natural plants that can be extracted some various pharmaceutical substances. These substances are considered as organic chemistry that is absolutely safe to cure by naturopathy, also known as “Thai traditional home remedy”. From the historical stone inscription, King Ramkhamhaeng of Sukhothai has inscribed the reference treatise that healers cultivated and used these herbal plants to cure the king’s people (Masao, 1908). As well as Simon de La Loubère – a French diplomat who wrote a cultural and living description about Suvarnabhumi zone to the Emperor Louis XIV of France that had some contextual information about the traditional herbal and pharmaceutical plants (Love, 1994). Later the first medicinal prescription in Thailand was originated by the King Ramathibodi III (or King Narai) of Ayutthaya, also known as “the original King Narai’s pharmacopeia” (Hodges, 1999). Until now, Thailand is one of the best herbal agricultural sources that export many various medicinal herbs as a main material to many international pharmaceutical companies. In a nutshell, Thai herbal plants can be seen as “Thai treasure and worthiness” that should be conserved to the young generation.

Despite Thailand as one of the world’s herbal sources, many Thai youths do not perceive/identify clearly Thai herbs and their essential properties. This paper builds an intelligent computer model based on object detection to identify Thai herbs and their properties. Even some herbal identification applications (Pornpanomchai & Rimdusit, 2011; Arun, et al., 2013; Janani & Gopal, 2013; Satti, et al., 2013; de Luna, et al., 2017) are available; these works are based on traditional hand-crafted models (in term of “Bag of words”) with dimensionality reduction. Since the hand-crafted model was proven to be outperformed by the convolutional neural network (CNN) in term of classification accuracy (Zhao, et al., 2018; Zheng, et al., 2018), known as AlexNet (Krizhevsky, et al., 2012) in the Large Scale Visual Recognition Challenge (ILSVRC) as well as food identification (Mookdarsanit, et al., 2018) that is well-known for having so many local features of ingredients. Until now, many applications have gradually replaced the hand-crafted models by CNN. However, a well-known CNN approach for Chinese-herbal identification (Sun & Qian, 2016) based on Region-CNN (R-CNN) (Girshick, et al., 2014) is available. The concrete R-CNN architecture has its multistage complex pipeline and is trained by SVM classifiers that are known as expensive, especially in memory

consumption and runtime (Mookdarsanit, et al., 2019). This paper uses the Fast R-CNN (Girshick, 2015) architecture to identify the Thai herb from an image. For model creation, many Thai-herbal images with their medicinal properties are trained to the Visual Geometry Group Network (VGGNet) architecture (Simonyan & Zisserman, 2014). Firstly, the multiple regions of interests (RoIs) of an image as the feature maps are extracted by a two-stage framework (known as Fast R-CNN). After that, the feature maps as RoI vector are trained to Visual Geometry Group Network (VGGNet) architecture. Finally, an unknown herbal image can be identified by the built model.

In this paper, we used 2,700 arbitrary herbal images as our primary dataset of the 11 medicinal herb types: Siamese Rough-bush, Cumin, Holy Basil, Sweet Basil, Cha Muang, Kaffir-lime Leaf, Siamese Morning-glory, Pandanus Leaf, Mint, Chinese Kale and Chaplu, as shown in Figure 1.” The environmental backgrounds of herbal objects were one-tone scene and taken by iPhone 4s, Sony E PZ 16-50mm F3.5-5.6 OSS and Huawei P30 Pro.

This paper is organized into 5 sections (including introduction). The section 2 describes about Fast R-CNN Framework, VGGNet Architecture are explained in section 3 and 4. Finally, the conclusion is in section 5.

2. Fast R-CNN Framework

Fast R-CNN is an end-to-end detection which is either speed or accuracy. Since the concept of R-CNN shares the computation of convolution over many region proposals and the Region of Interest (RoI) Poolings are added in the middle between the last convolutional (CONV) layer and the first Fully-connected (FC) layer.

2.1 Convolution with ReLU

Thai herbal image passes the convolution with filters and receptive fields. All CNN filters within the same convolutional layer have the same size but different parameters.

In each convolutional layer, all Region of Interests (RoIs) of a leaf are extracted by complementary similarity measures that consist of color similarity, texture similarity, size integration and grown-region consistency.

For color similarity ($s_{color}(r_i, r_j)$) by (1), each region (r_i) measured by 25 bins of color histogram $C_i = \{c_i^1, c_i^2, \dots, c_i^n\}$ using L_1 norm. The configuration of $n = 75$ is tuned in case of 3 (RGB) color channels.

$$s_{color}(r_i, r_j) = \sum_{k=1}^n \min(c_i^k, c_j^k) \quad (1)$$

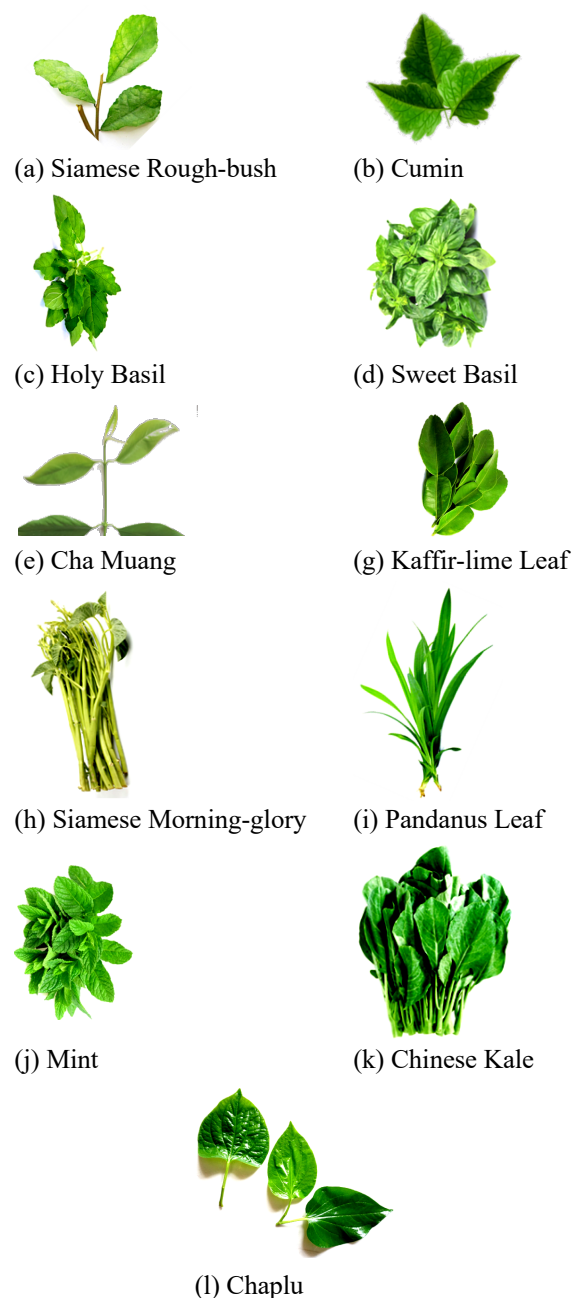


Figure 1. Some medicinal taxonomy of Thai herbs

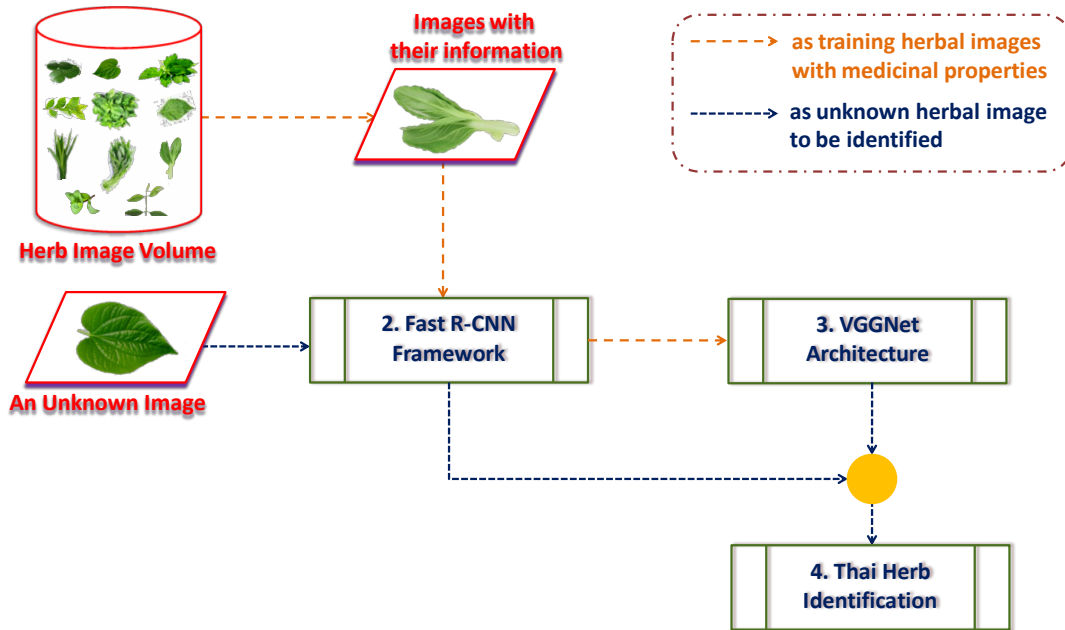


Figure 2. The overall framework of Thai herb identification with medicinal properties

For texture similarity ($s_{texture}(r_i, r_j)$) by (2), the Gaussian derivatives in 8 orientations is done by $\sigma = 1$ in each color channel. The 10 bins are allocated for each orientation of each color channel $T_i = \{t_i^1, t_i^2, \dots, t_i^n\}$ where $n = 240$ for 3 channels.

$$s_{texture}(r_i, r_j) = \sum_{k=1}^n \min(t_i^k, t_j^k) \quad (2)$$

For size integration ($s_{size}(r_i, r_j)$) by (3), the related small regions are decided to grow together to ensure the object location for all pyramid scales.

$$s_{size}(r_i, r_j) = 1 - \frac{size(r_i) + size(r_j)}{size(im)} \quad (3)$$

For grown-region consistency ($fill(r_i, r_j)$) by (4) that measures how consistent the mergence between r_i and r_j is. The bounding box ($size(BB_{ij})$) is a representative of integration between r_i and r_j . In case of the hardly touching between r_i and r_j , these regions are not merged.

$$fill(r_i, r_j) = 1 - \frac{size(BB_{ij}) - size(r_i) - size(r_j)}{size(im)} \quad (4)$$

In a nutshell, the RoI ($x(r_i, r_j)$) are extracted by (5), where $0 \leq a_i \leq 1$

$$x(r_i, r_j) = a_1 s_{color}(r_i, r_j) + a_2 s_{texture}(r_i, r_j) + a_3 s_{size}(r_i, r_j) + a_4 fill(r_i, r_j) \quad (5)$$

Finally, the activation functions of these RoIs along gradient-based learning is approximated by Rectified Linear Unit (ReLU), where $ReLU(x) = \max(0, x)$.

2.2 RoI Max Pooling

Before the max pooling, a linkage between convolutional layers is called the feature maps that contain RoIs. The feature maps ($Map_{Feature}$) from previous layers are embedded with kernels/receptive fields (k_{ij}^l) and biases (b_{ij}^l) that go to ReLU function. Each input feature maps of current layer inherit from previous output feature maps of previous layer as (6), where M_j is a selection of input maps.

$$x_j^l = Map_{Feature} \left(\sum_{i \in M_j} x_i^{l-1} \bullet (k_{ij}^l + b_{ij}^l) \right) \quad (6)$$

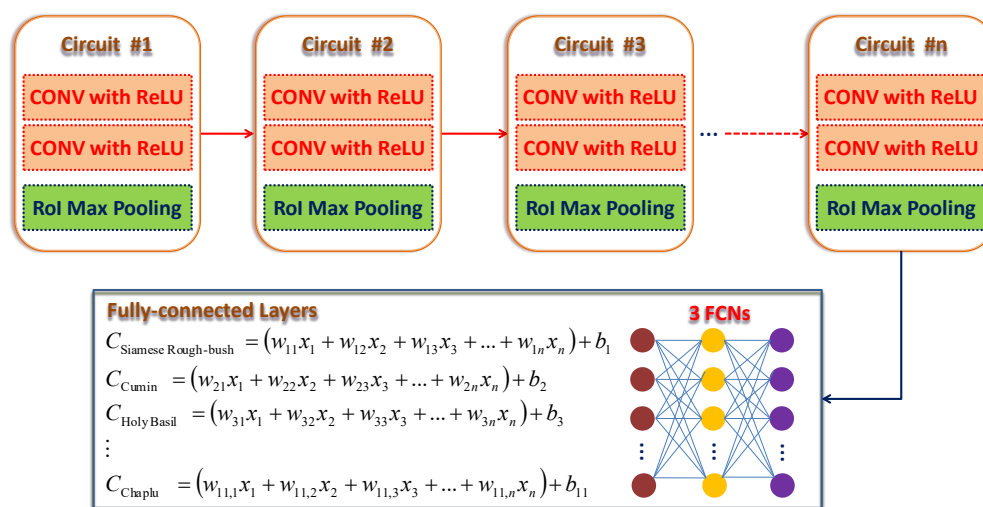


Figure 4. The Visual Geometry Group Network (VGGNet) Architecture

Later, the max pooling is used to reduce the dimension of output maps from previous layer that also can be implemented under the architecture of multi-scale pyramid pooling as shown in Figure 3.

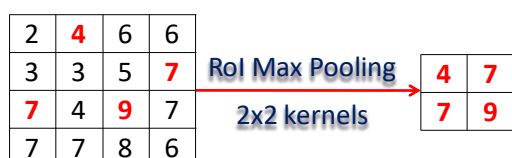


Figure 3. The 2x2 kernels of RoI max pooling

3. VGGNet Architecture

Visual Geometry Group Network (VGGNet) is a learning-based hierarchical architecture, including the convolution layers with ReLU activation functions and RoI Max-pooling layers in terms of vectors with scalar values. Finally, the Fully-connected layers build the class of each herb ($C_{herbal\ name}$) that use the concept of biases (b_i) and weights (w_{ij}) coupled with the extracted RoIs as parameters by (7).

$$\begin{aligned}
 C_{Siamese\ Rough-bush} &= (w_{11}x_1 + w_{12}x_2 + w_{13}x_3 + \dots + w_{1n}x_n) + b_1 \\
 C_{Cumin} &= (w_{21}x_1 + w_{22}x_2 + w_{23}x_3 + \dots + w_{2n}x_n) + b_2 \\
 C_{Holy\ Basil} &= (w_{31}x_1 + w_{32}x_2 + w_{33}x_3 + \dots + w_{3n}x_n) + b_3 \\
 &\vdots \\
 C_{Chaplu} &= (w_{11,1}x_1 + w_{11,2}x_2 + w_{11,3}x_3 + \dots + w_{11,n}x_n) + b_{11}
 \end{aligned} \quad (7)$$

As shown in Figure 4, the initialization of VGGNet training is done by 2,700 herbal images with their textual medicinal properties. All features of each image (like color, texture, size and grown-region similarities) are mapped in term of 134M

parameters by Fast-CNN and classified by 3 Fully-connected layers.

4. Thai Herb Identification

An unknown herbal image inputs to identify itself with its medicinal properties by CNN-based model according to Figure 5.

The unknown herbal image is extracted the RoIs using Fast-RCNN Detection that consists of recursive convolutional layers and RoI Max Pooling layers. Later, the VGGNet architecture considers these extracted RoI features with other parameters like biases and weights to identify the herb and its medicinal properties.

The unknown herbal image identification is statistically computed by the conditional probability of FCN-based output classes by (8).

$$\begin{aligned}
 P_{FCN}(C_{herbal\ name} | x_i, (w_{i1}, w_{i2}, \dots, w_{in}, b_1, b_2, \dots, b_{11})) \\
 = \frac{e^{w_y + b_j}}{\sum_{j=1}^{11} e^{w_y + b_j}}
 \end{aligned} \quad (8)$$

where $C_{herbal\ name}$ is any target classes of the 11 herbal types, the max probability $\max(P_{FCN}(C_{herbal\ name}))$ is selected to identify the herb with its properties.

For the model evaluation, we used the recall and precision (as (9) and (10)) to measure our CNN-based model to identify the herb and its medicinal properties.

$$recall = \frac{TP}{TP + FN} \quad (9)$$

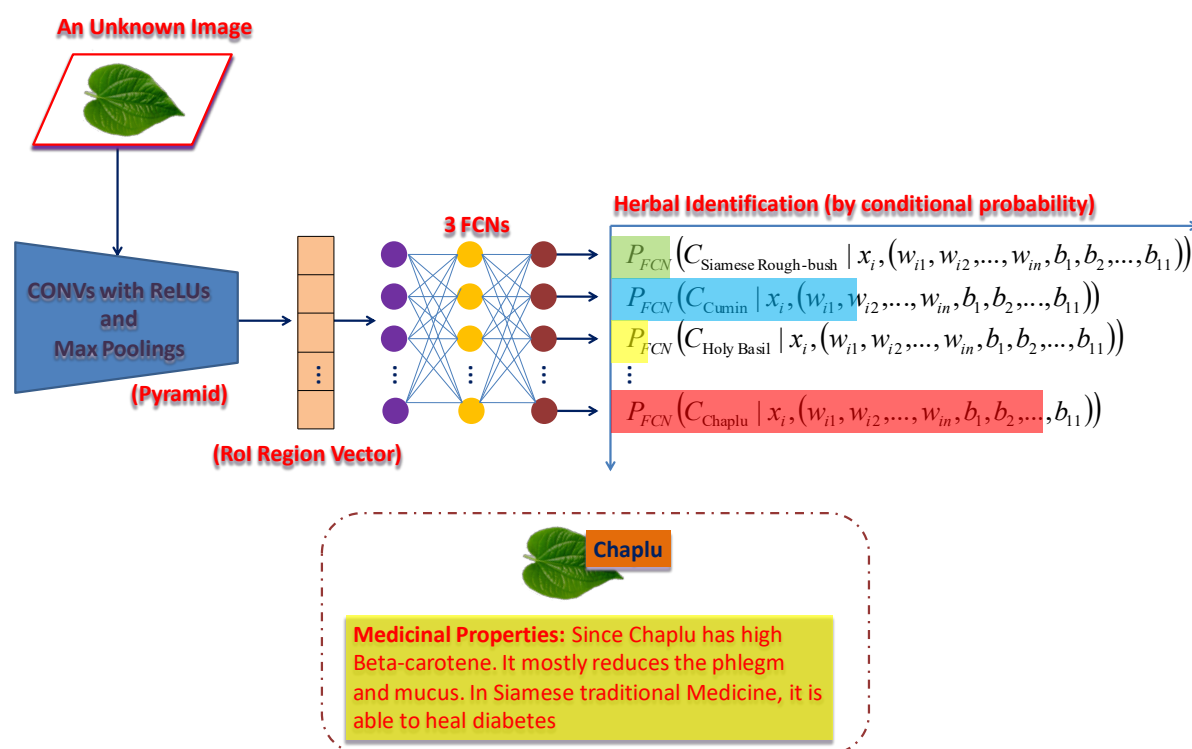


Figure 5. Herb identification with medicinal properties

$$\text{precision} = \frac{TP}{TP + FP} \quad (10)$$

where TP (True Positive) means “a number of herb A(s) and the model identifies correctly as the herb A”, TN (True Negative) means “a number of not other herbs, the model identifies correctly as not the herb A”, FP (False Positive) means “a number of not other herbs, the model identifies wrongly as the herb A” and FN (False Negative) means “a number of herb A(s), the model identifies wrongly as not the herb A”

5. Results and Discussion

The results with amount of herbal images are shown in Table 1. Since Pandanus Leaf has their own physical distinctiveness in shape and texture that totally differs from other herbs to be the highest correctness in term of recall precision. However, Cumin and Chaplu sometimes look very similar that easily causes the misidentification. As well as Holy Basil, Sweet Basil and Mint that are not too much different that physically affects the differentiation between them.

Since those arbitrary herbal images are taken from different recorders like mobile phones and cameras that make the same herbal images may have different operations like resolution,

distribution, texture or background. Therefore, the herbal identification may produce some errors. Overall errors (computed by $FP+FN$) are shown in Figure 6.

Table 1. The herb identification's evaluation

Herbal Name	Amount of Images	Recall	Precision
Siamese Rough-bush	245	0.85	0.82
Cumin	245	0.78	0.86
Holy Basil	248	0.81	0.83
Sweet Basil	247	0.89	0.92
Cha Muang	245	0.95	0.92
Kaffir-lime Leaf	240	0.95	0.99
Siamese Morning-glory	245	0.91	0.92
Pandanus Leaf	244	0.99	1.00
Mint	245	0.82	0.82
Chinese Kale	248	0.95	0.94
Chaplu	248	0.88	0.81

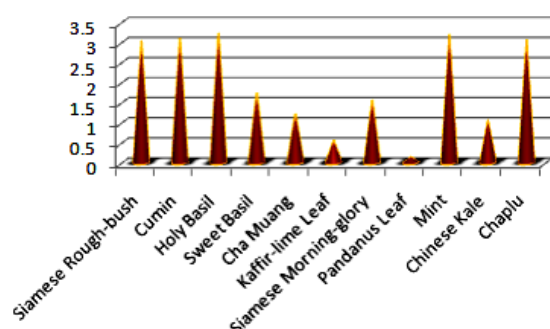


Figure 6. Overall errors ($FP+FN$) in percentage

As shown in Figure 7, the comparison between those traditional hand-crafted herbal identification (Pornpanomchai & Rimdusit, 2011; Arun, et al., 2013; Janani & Gopal, 2013; Satti, et al., 2013; de Luna, et al., 2017) and CNN-based model (Sun & Qian, 2016) and ours are compared based on the amount of data (Alom, et al., 2018). If there are a small-sized number of images to train the computer model, the hand-crafted based recognition has more performance than CNN. On the other hand, CNN is totally better if a large-scale amount of images are trained to the model.

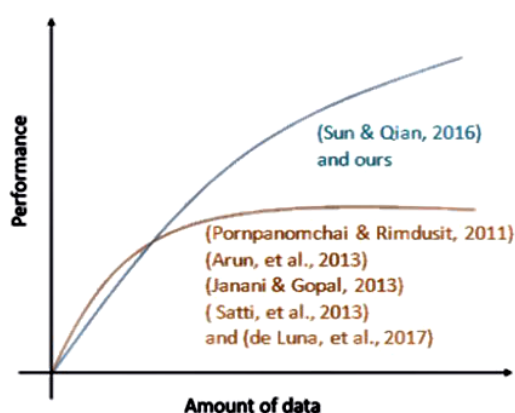


Figure 7. Comparison between hand-crafted and CNN approaches

According to the big data decade, the performance of CNN approaches have become more compatible in large-scale problems, known as the more volume, veracity, velocity and variety of image data. In case of image data insufficiency, a large number of images with the same distribution can be autonomously generated by transfer learning like Generative Adversarial Network (GAN) with Auto Encoder (AE) (Giuffrida, M.V., et al., 2017). Moreover, there are another some secondary data about CNN-based comparison (Liu, et al., 2018) between R-CNN (herbal identification by Sun & Qian and Fast R-CNN (ours) in Table 2.

Table 2. Comparison between R-CNN and Fast R-CNN framework

Framework	Dataset Pascal- VOC07	Dataset Pascal- VOC12
R-CNN based (by Sun & Qian, 2016)	0.58	0.53
Fast R-CNN based (ours)	0.70	0.68

6. Conclusion

Thai medicinal herbs are one of the treasure and worthiness since Sukothai era known as “Thai traditional home remedy”. It is not surprise that why Thailand is one of the biggest herbal agricultural sources for many well-known pharmaceutical companies. Still and all, many Thai youths do not perceive clearly Thai traditional herbs and their essential properties. In this paper, we build a CNN-based model to identify the herb and its medicinal properties from an unknown image. The Fast-RCNN framework is applied to extract CNN-features from 2,700 herbal-tagged images with their medicinal properties that cover 11 herbal types: Siamese Rough-bush, Cumin, Holy Basil, Sweet Basil, Cha Muang, Kaffir-lime Leaf, Siamese Morning-glory, Pandanus Leaf, Mint, Chinese Kale and Chaplu. And the learning model is built by Visual Geometry Group Network (VGGNet). For the model evaluation, the overall recall is higher than 0.75 and the precision is higher than 0.80. Moreover, the same herb taken from different devices with various resolutions may produce the misidentification.

For future works, the improvement of image resolution can be done using the power-law-adaptive sample generation by Generative Adversarial Network (GAN) coupled with Auto-encoder (AE). Moreover, these self-supervised approaches are able to generate more than 10,000-100,000 large-scale images from the collection of original primary images by randomized adversarial perturbation.

7. Acknowledgement

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