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AN EXPERT-SYSTEM FOR ANALYSING RELATIONSHIPS BETWEEN FISH AND ENVIRONMENT

by

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Summary

An ecological expert-system built by the expert-system-shell AUTOKLAS is proposed.
AUTOKLAS doesn't work rule orientated like traditional expert-systems , but it is based on pattern recognition.
The method is explained by a knowledge base of the fisheries on Sebastes mentella in the Irminger Sea.
Following knowledge bases in oceanography , physiology and meteorology will be realized in future .
The application of the described method may also recommended, to solve other complex ecological questions.

Introduction

Expert-systems are computer based systems, used to determine knowledge of experts and make it available to a wider circle of users.
Such systems will play an important role to solve complex problems.
Mostly expert-systems work rule orientated. Therefore experts introduce their experience in knowledge bases.
By the help of software tools will give a set of rules to the computer.

Another way to built up knowledge bases, is the usage of the pattern recognition method. Here are the rules established internally in the form of patterns.
The used expert-system-shell AUTOKLAS simulate the human spirit in the following way:
The expert (fishery biologist or fishery hydrograph) uses his knowledge to explain a special situation in fishery.
He recognizes the situation on the base of features. These features are the measured parameters of the environment.
The system is working in classes. The humane spirit works in the same way , for instance people say there are high catches , normal catches and low catches. These quantity classes will be set in to relation to the environment.
The case is difficult to solve, because there are too mutch parameters influencing the catch.
An expert-system helps by giving some informations.
The construction of one knowledge base will explained.

Material

Data were collected during the redfish-survey of R/V "E.Haeckel" in the Irminger Sea from April to May 1988.
30 fishery trawls were carried out.
We deviced the redfish-catches to classes:

class 1 = hight catch
class 2 = normal catch
class 3 = low catch

Nautical data and abiotic parameters are the features. There influence on the catch quantity will be determine.

feature 1 : DAY
= day in the year
feature 2 : UTCDOWN
= minutes from 00.00 UTC till net goes down
feature 3 : NORTHDOWN
= latitude
feature 4 : WESTDOWN
= longitude
feature 5 : UTCUP
= minutes from 00.00 UTC till net comes up
feature 6 : NORTHUP
= latitude
feature 7 : WESTUP
= longitude
feature 8 : WINDDIR
= direction of wind
feature 9 : BEAUFORT
= beaufort
feature 10 : DIFFBEAU
= difference to the day before
feature 11 : HPASC
= atmospheric pressure
feature 12 : DIFFHPASC
= difference to the day before

feature 13 : SST
= sea surface temperature
feature 14 : CATCHTEMP
= temperature in depth of catching
feature 15 : CDEPTH
= depth of catching
feature 16 : TTHOUR
= trawl time in hours
feature 17 : COURSE
= course in degrees
feature 18 : SPEED
= trawl speed in knotes
feature 19 : CLOUDE
= 1 blue sky
= 2 cloudy
= 3 overcast
feature 20 : OPENING
= opening of the net in meter

Method

30 vectors (catching classes with the features) which were inputed are the knowledge base of the system.
AUTOKLAS makes an extraction step. The objectiv of the extraction is an intern classifikation.
The selection of good features for describing the catch-quantity is supported by the ranking analyse and the feature-estimating-test.
In our knowledge base will only use features, which show - single or in connexion with other features - good relations to the defined classes.

Ranking of features

		Score
1.	NORTHUP	0.00
2.	WESTUP	0.00
3.	NORTHDOWN	0.00
4.	WESTDOWN	0.00
5.	UTCUP	1.67
6.	UTCDOWN	2.00
7.	SST	3.00
8.	TTHOUR	4.67
9.	DAY	5.00
10.	COURSE	5.00
11.	CLOUDE	5.00
12.	CATCHTEMP	5.50
13.	DIFFBEAU	5.83
14.	CDEPTH	6.50
15.	DIFFHPASC	6.50
16.	HPASC	7.50
17.	WINDDIR	8.00
18.	SPEED	8.50
19.	BEAUFORT	8.67
20.	OPENING	9.67

AUTOKLAS is using for every feature special patterns:
For example: CATCHTEMP

LL		HL		classes 1	2	3		Score
4.30	1	4.35	1		1		2	0
4.35	2	4.43	2	1			1	0
4.43	3	4.70	4		1	1	3	1
4.70	5	4.85	5			1	3	0
4.85	6	4.93	6	1			1	0
4.93	7	5.03	8	1		1	3	1
5.03	9	5.15	12	2	1	1	1	
5.15	13	5.62	16		4		2	0
5.62	17	5.75	17			1	3	0
5.75	18	6.06	22	1	2	2	1	
6.06	23	6.23	26	3		1	1	1
6.23	27	6.40	28	1	1		2	1
6.40	29	6.80	30		2		2	0
		total		10	12	8		4

LL = lower limits
HL = higher limits
of the intern defined temperature intervalls

Column 2 and 4 gives the quantity of trawls in every temperature intervall.
The quantity of high, normal and lower trawls in each temperature intervall is shown in column 5, 6 and 7.
The dominant catching class is standing in the last but one column.
The score in the last column said something about the quality of the features. The comparison of the total scores of each feature gives the ranking of all features. By this mean it is possible to select good features. (The best features have the lowest scores.)

AUTOKLAS create intern 26 patterns.
Pattern 13 looks for instance like this:
15;13;15;18;10;24;15;5;6;6;2;11;10;5;6;10;3;1;1;2
Classes:
1 0 0

The first row of data shows for each feature one value. The value is the intervall from the feature pattern. In the 14'th position for example (feature temperature in catching depth) stands number 5 , this means that in the fifth temperature intervall were done one hight catch. These hight catch will from AUTOKLAS seen in connexion with feature intervalls from the other parameters.By this fact the system relates and classifies in n-dimensional space.

Results and discussion

1.The ranking of the features gives in connexion with the feature-estimating-modul reference to what features must be use for a good catch classification.

2.The information mode of the expert-system:

Example:

feature	value
DAY:	102.00
UTCDOWN:	565.00
NORTHDOWN:	6102.00
WESTDOWN:	3020.00
UTCDOWN:	625.00
NORTHUP:	6058.00
WESTUP:	3027.00
WINDDIR:	40.00
BEAUFORT:	5.50
DIFFBEAU:	-1.50
HPASC:	1022.00
DIFFHPASC:	-4.00
SST:	6.52
CATCHTEMP:	6.50
CDEPTH:	330.00
TTHOUR:	1.00
COURSE:	220.00
SPEED:	5.40
CLOUDE:	2.00
OPENING:	50.00

The case shows components of the following classes

Hight catch	with p=29.82 %
Normal catch	with p=61.40 %
Low catch	with p= 8.77 %

This case should belong to class normal catch.

The information mode allows to simulate special situations. Inputed data will compare with given patterns.
If bad data will computed , AUTOKLAS devices the case back (dependend from classificator).
The input of an usable vector can be done in the learning mode. By this way the system is able to learn.

The shown example of one knowledge base , allowes to estimate the possibility of building an complex expertsystem. In this way it will be better to structure all fields influencing the catch.

Example for an structured complex expertsystem :
(KB = knowledge base)
In the information mode we start at the top and go to the bottom.

KB area
classes: different areas

KB time
classes: 1.week ; 2.week ; .... ; n.week

KB fish species
classes: Sebastes mentella ; Sebastes marinus

KB physiology
classes: prespawn ; spawn ; postspawn

KB oceanography
classes:(hydrological phases) become warm ; warm ; cool

KB meteorology
classes: further or prevent concentration of fish

One example of an oceanographic knowledge base were alredy improved (FUCHS and STEIN 1991).
The structured fixing of knowledge has the following advantages:

- The work will be done step by step.
- The specialists introduce in each step their experiences
- The logical coonexion of the knowledge bases is optional

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