Machine Learning approach in Prediction of Surgical Outcome

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Introduction

Fact:

- Medical Informatics and biomedical computing have grown in measure over the past decade.

- However, there is a lack of effective analysis tools to discover hidden relationships and trends in data.

Challenges of medical Informatics:

- To acquire proficiency in understanding and interpreting clinical information.

- To apply this through making prudent treatment decisions.

Results:

- Predictability in surgery improves the overall results and the expectations of both surgeon and patient, influencing positively their relationship reflected also in preoperative informed consent.

Introduction to peripheral nerves surgery

Peripheral nerve needs surgical treatment in case of traumatic injury, entrapment or tumor.

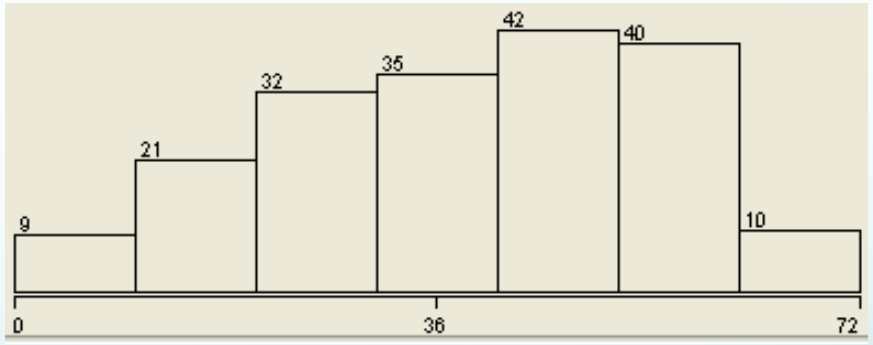
Factors that affect nerve recovery process:

- *timing from the onset of nerve disease to surgery*
- *distance of repaired nerve from the muscle*
- *type of nerve repair*
- *age*
- *sex*
- medical conditions

Clinical data

Data of patients operated on for nerve injury during three years period: January 2006 until December 2008 at Service of Neurosurgery, Univ Hosp Centre MT, Tirana

- **Sex** - 110 males : 79 females.
- **Age**
  - Maximum 72 years old
  - Minimum <1 year old
  - Mean 38.878



Clinical data

- **Lesion**

Lesion Type	Patients
entrapment	91
traumatic	90
tumor	8

- **Location**

Location	Patients
High, proximal	141
Low, distal	31
Brachial plexus	15
Lumbar plexus	2

Clinical data

- **Trauma**

Type	Count
Others	100
Neurolysis	45
Transplant	40
Neurorafia	4

Distance from lesion to most distal part of the nerve

- Minimum 0 (in case of amputation)
- Maximum 120 cm
- Mean 21.804 cm

- **Transplant length**
  - Minimum 0 (no transplant; end-to-end suture)
  - Maximum 12 cm
  - Mean 0.989 cm

Clinical data

The **time** passed from the onset of the disease to surgery

- Minimum 0
- Maximum 231 months
- Mean 19.81 months

Evaluation

To evaluate nerve recovery we use an integer value from **0-3:**

0 : patient doesn't feel any recovery at all

1 : the range of the recovery in the interval 0 -35%

2 : the range of the recovery is between 35% and 70 %

3 : the range of the recovery is greater than 70 %

The evaluation is done at the end of one month, three months, six months and one year.

The result is expressed as: low, middle , high.

Machine learning algorithms

J48 (is the implementation of the C4.5 decision tree algorithm)

These models take a"divide-and-conquer" approach: a complex problem is decomposed in simpler sub-models and, recursively, this technique is applied to each sub-problem

Powerful classification algorithms and is often used in medicine for the prediction.

Naïve Bayes

Strong assumption that all the attributes are independent.

The algorithm tends to perform well in many class prediction scenarios.

PART

Constructs a rule set on the basis of information gain ratio.

This implies that the obtained rule sets are biased with the correctness of each classification problem.

Algorithms Comparision (10 cross validation)

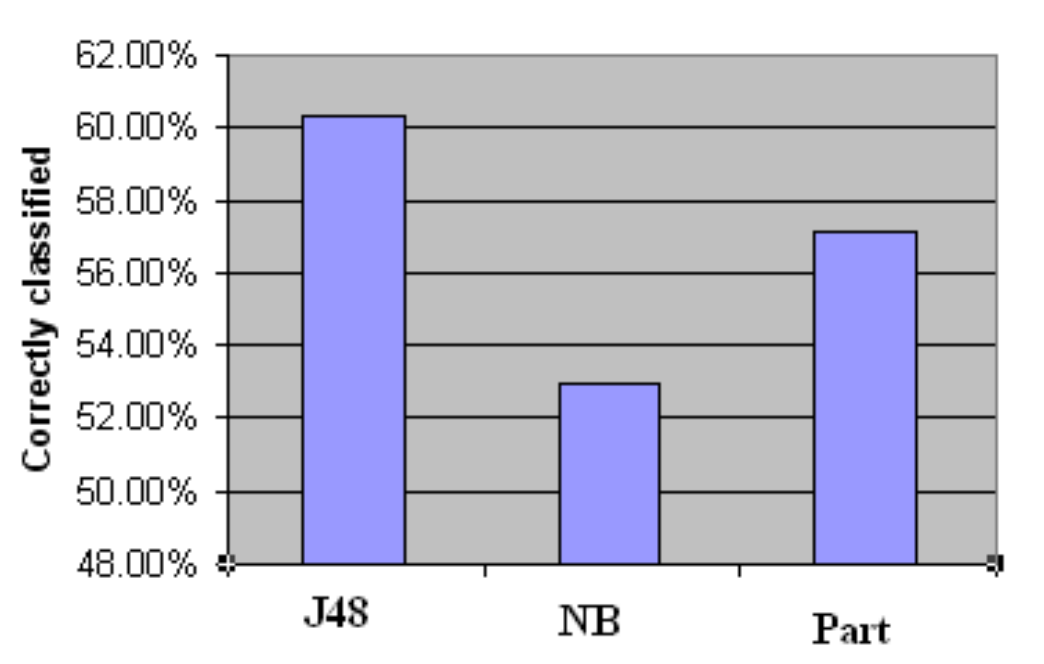
Evaluation Criteria	Classifiers		
	J48	NB	Part
Kappa statistic	0.3328	0.2374	0.2855
Mean absolute error	0.3368	0.3426	0.3435
Root Mean Squared Error	0.4389	0.4709	0.4431
Prediction accuracy	60.3175 %	52.9101 %	57.1429 %

Table 1: Comparison of Performance using 10 cross validation

Classifier	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
J48	0.603	0.271	0.6	0.603	0.592	0.657
NB	0.529	0.28	0.579	0.529	0.528	0.669
Part	0.571	0.282	0.566	0.571	0.564	0.657

Table 2: Detailed accuracy by class (average values)

Comparison of Algorithms Accuracy using 10 cross validation

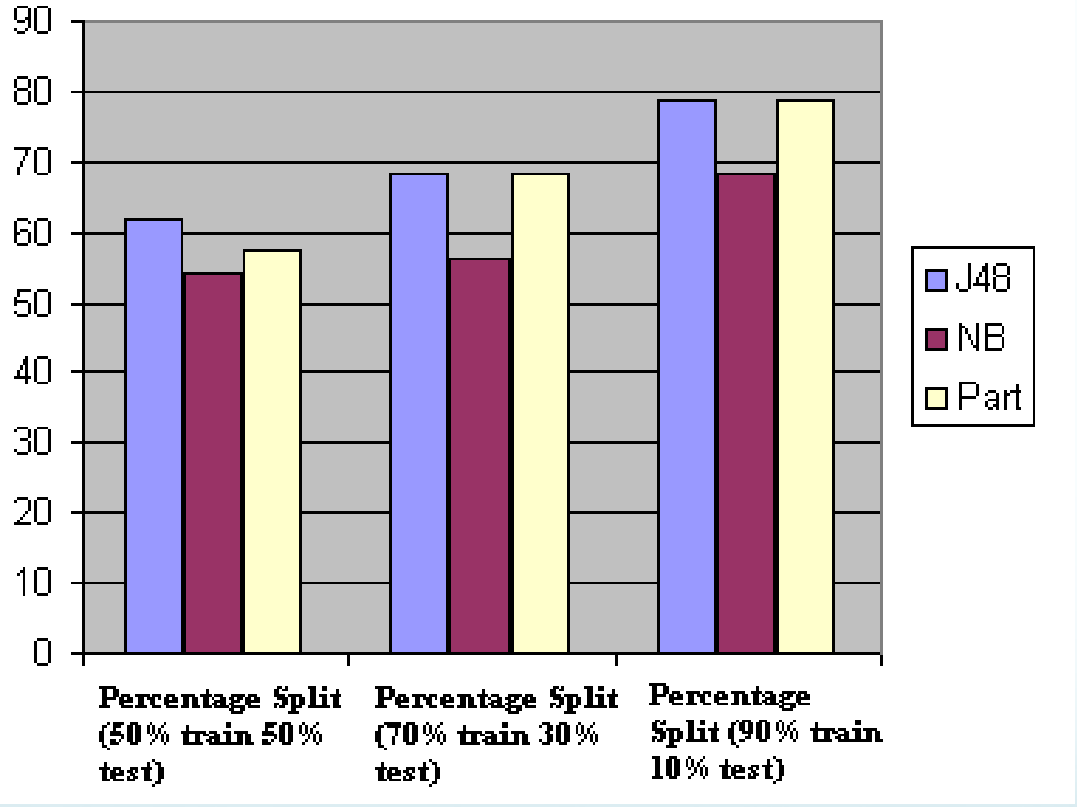


Algorithms Comparision (percentage split)

Criteria of Testing	Machine Learning algorithms		
	J48 Accuracy(%)	NB Accuracy(%)	Part Accuracy(%)
Percentage split (50% train, 50% test)	61.70	54.25	57.44
Percentage split (70% train, 30% test)	68.42	56.14	68.42
Percentage split (90% train, 10% test)	78.94	68.42	78.94

Table 3: Comparison of Performance using percentage split

Comparison of Algorithms Accuracy using percentage split



Conclusion of the study

- When 10 fold cross validation is used , J48 predicts better than other algorithms. The accuracy rate of Naïve Bayes classifier is the lowest among the three machine learning techniques.
- When percentage split is used the highest accuracy was observed in the case of decision-tree induction algorithm (J48) for the three percentage splits (50%,70 % and 90 %).
- However when the split is 70 % and 90% Part algorithm accuracy was equal to the accuracy of J48 algorithm. Their accuracy curve are unstable when the data is spilt into training and test.
- Naïve Bayes shows stable accuracy for the same dataset. The accuracy rate of Naïve Bayes is the lowest among the three algorithms.

Future work

- We are planning to expand our work in these directions:
- 1) developing models based on more predictors
- 2) application of other machine learning techniques and approaches
- 3) training and testing on larger and more diversified data sets.