Application of Decision Tree for Detecting Learning Disabilities in Children

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***Abstract*—Decision tree is an improved concept of tree from discrete mathematics. Decision tree is a simple but powerful form of multiple variable analysis. It has been used in many sectors, one of them is education such as detecting learning disabilities.**

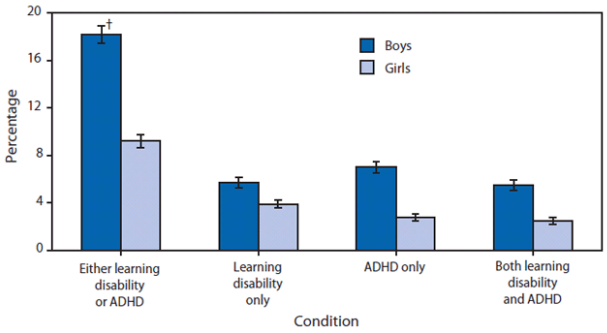
This paper will discuss further how decision tree can predict learning disabilities. The problem which there are neurological disorder in children's brains. In this context, decision tree is applied to support the decision making. By harnessing the decision tree, we can understand whether a child is facing learning disability or not together with its error as well.

***Keywords*—Decision Tree, Learning Disabilities, Discrete Mathematics, Education.**

I. INTRODUCTION

Learning disability has been big issues over the world. No matter a country is developing country or developed country, learning disability still become the big concern in their country. According to an organization in UK [11] :

a. It is estimated that there are 286,000 children (180,000 boys , 106,000 girls) age 0 -17 in the UK with a learning disability
b. Approximately 200,000 children in England are at the School Action Plus stage of assessment of SEN or have a Statement of SEN and have a primary Special Educational Need (SEN) associated with a learning disability. Of these, four out of five have a moderate learning difficulty, one in twenty have profound multiple learning difficulties.
c. In very early childhood, only severe learning disabilities are more likely to have a learning disability
d. Overall, 89% of children with moderate learning difficulty, 24% of children with severe learning difficulty and 18% of children with profound multiple learning difficulty are educated in mainstream schools.



Source :
http://www.cdc.gov/mmwr/preview/mmwrhtml/figures/m5935qsf.gif

Figure 1.1 Learning Disability in Children Statistics according to CDC.

A learning disability is a neurological disorder. In simple terms, a learning disability results from a difference in the way a person's brain is "wired." Children with learning disabilities are as smart as or even smarter than their peers. But they may have difficulties in reading, writing, spelling, reasoning, recalling and/or organizing information if left to figure things out by themselves or if taught in conventional ways. Learning disabilities are different between a child and other children. One child with learning disabilities may not have the same kind of problems as another child with LD. [1]

A learning disability can't be cured or fixed. It is a lifelong issue. With the right support and intervention, however, children with learning disabilities can succeed in school and go on to successful, often distinguished careers later in life. Learning disabilities affect children not only academically, but socially as well.

Specific learning disabilities have been recognized in some countries for much of the 20th century, in other countries only in the latter half of the century, and yet not at all in other places [2]. These may be detected only after a child begins school and faces difficulties in acquiring basic academic skills. A learning disability can cause a child to have trouble learning and using certain skills.

The skills most often affected are: reading, writing, listening, speaking, reasoning and doing math [3]. If a child has unexpected problems or struggling to do any one

of these skills, then teachers and parents may want to investigate more

Parents can help children with learning disabilities achieve such success by encouraging their strengths, knowing their weaknesses, understanding the educational system, working with professionals and learning about strategies for dealing with specific difficulties.

Therefore, detecting this problem immediately is really essential thing to help these children reach their success. Decision tree can support us to overcome this problem.

Source : http://www.indiaparenting.com/pics/detect-learning-disabilities-in-kids.jpg

Figure 1.2 Child Affected with Learning Disability

Source : http://education-portal.com/cimages/multimages/16/Types-Of-Learning-Disabilities-Umbrella.jpg

Figure 1.3 Learning Disability Type

II. THEORY

II.1 Tree

In *Discrete Mathematics and Its Applications*, Rosen explained that tree is undirected graph that doesn't have circuit [4].

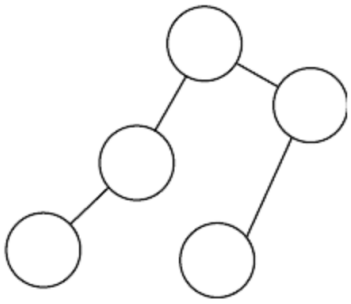


Figure 2.1 Example of Tree

When a tree is represented as directed graph, we can say that it is rooted tree. Rooted tree has some properties [5] :

1. If the tree has n nodes, so the number of edge is n-1.
2. Tree has special node called root.
3. Tree has special node called leaf.
4. Each node is situated at a level.

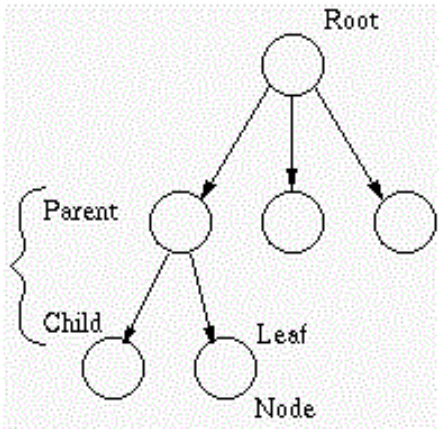


Figure 2.2 Example of Rooted Tree

II.2 Decision Tree

Decision tree is development from the tree concept on discrete mathematics that is used as support tool in making decision that very branch of the tree may have their own probability. For example, in Binary Search Tree we can determine a decision from answering the facts (root and internal nodes) with "yes" or "no". So, we can come up with a solution in leaf. That tree is called decision tree.

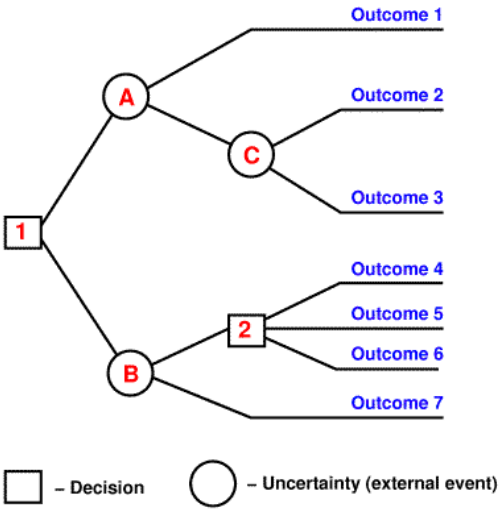
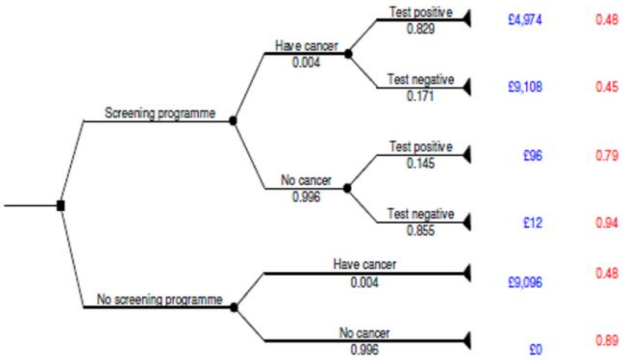


Figure 2.3 Example of General Decision Tree



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http://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2012-2013/Makalah2012/Makalah-IF2091-2012-058.pdf

Figure 2.4 Example of Decision Tree in Health

II.3 ID3, C4.5, and J48 Algorithm

a. ID3 Algorithm

ID3 (*Iterative Dichotomiser 3*) is an algorithm that is used to build a decision tree. It is found by J. Ross Quinian by harnessing *Information Theory* of Shanon.

The main idea of this algorithm is build tree with the most significant attribute as initial branch of the tree. In this context, "significant" means an attribute that is considered to be able to differentiate "yes" or "no" in large area of the case. [7]

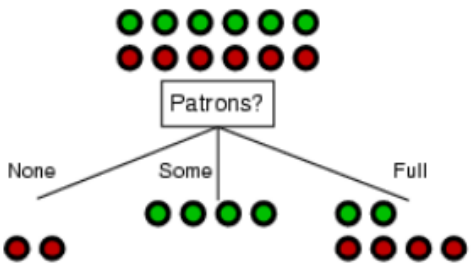


Figure 2.5 "Patrons" Filtering Attribute

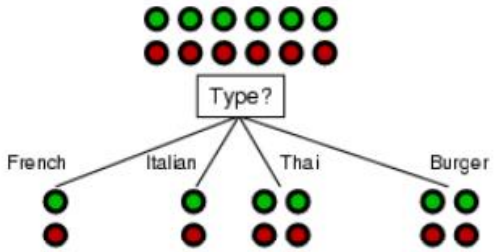


Figure 2.6 "Type" Filtering Attribute

In figures above, we can see that each branch consists of green or red only. Although the branch "full" contains two colors, we can see that the "patron " filtering is better than "type" filtering.

b. C4.5 Algorithm

This algorithm is the development of ID3. The differences between C4.5 and ID3 are :

- C4.5 is able to handle discrete or continuous attributes
- C4.5 is able to handle the missing value or empty attribute.

c. J48 Algorithm

This algorithm is an implementation of C4.5 algorithm in WEKA, open source of data mining application that basis on Java.

II.4 Decision Making

Decision making is really important in our daily life. If, we are facing difficulties, making the best decision will affect our next activities, otherwise, we will face more difficulties. To make decision, there are some methods that we can use. One of them is using decision tree and then select the best decision according to the circumstances. Decision making using decision tree method sure has both advantages and disadvantages.[6]

Some advantages of decision tree :

a. Simple to understand because they can be visualized.
b. Requires little data preparation. Other methods require data normalization, dummy variables, and et cetera. By decision tree method, we don't need to do that.
c. According to Big-O notation, the complexity of using tree is logarithmic. It is more efficient than other method.
d. Able to handle both numerical and categorical data. Other techniques are usually can only handle one type of data.
e. Able to handle multi-output problems
f. Using a white box model. If a given situation is observable in a model, the explanation for the condition can be easily explained by boolean logic.
g. Possible to validate a model using statistical tests. So, we can depend on its reliability.

h. Can steadily perform well although its assumptions are somewhat violated by the true model from which the data were generated.

Some disadvantages of decision tree :

a. If the number of data or sample is quite big, decision tree learners can create over-complex tree so that the data is note generalized well.\
b. Decision tree can be unstable because small variations in the data might result in a completely different tree being generated.
c. There are some concept of decision tree that are hard to learn such as XOR, parity, or multiplexer problems.
d. Decision tree can sometimes create biased tree if some classes dominate. So, it will be important to use data that are quite balanced.

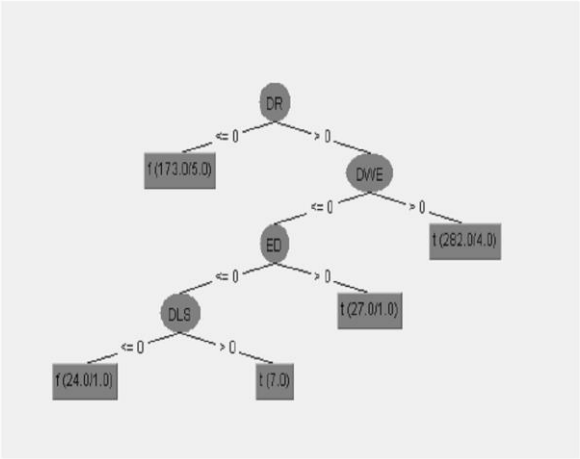
III. APPLYING THE DECISION TREE IN DETECTING LEARNING DISABILITIES

When a Learning Disability (LD) is suspected based on parent observations, a formal evaluation of the child is necessary. Nowadays, many types of assessment tests are available. For example, there is a checklist that consists of 16 symptoms of LD.

Table 3.1 Table of Learning Disabilities Symptoms

SI No.	Attribute	Signs & Symptoms of LD
1	DR	Difficulty with Reading
2	DS	Difficulty with Spelling
3	DH	Difficulty with Handwriting
4	DWE	Difficulty with Written Expression
5	DBA	Difficulty with Basic Arithmetic Skills
6	DHA	Difficulty with Higher Arithmetic Skills
7	DA	Difficulty with Attention
8	ED	Easily Distracted
9	DM	Difficulty with Memory
10	LM	Lack of Motivation
11	DSS	Difficulty with Study Skills
12	DNS	Does Not Like School
13	DLL	Difficulty Learning a Language
14	DLS	Difficulty Learning a Subject
15	STL	Slow to Learn
16	RG	Repeated a Grade

Then by using J48 Algorithm, we can construct the decision tree in detecting LD. In this construction, the selection of attribute is really essential because inconsistent data may causes to wrong prediction.



Source : Julie M. David et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2 (2) , 2011, 829-835829

Figure 3.1 Example of J48 Decision Tree According to LD Symptoms Table

TP Rate	FP Rate	Pre-cision	Recall	F Mea-sure	ROC Area	Class
0.984	0.030	0.981	0.984	0.983	0.968	T
0.979	0.022	0.964	0.979	0.972	0.969	F
Correctly Classified Instances					500 Nos.	97.47%
Incorrectly Classified Instances					13 Nos.	2.53%
Time taken to build a model						0.08Sec

Source : Julie M. David et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2 (2) , 2011, 829-835829

Figure 3.2 Example of LD Decision Tree Accuracy

There are also many kinds of decision tree that can be built according to the 16 attribute above. For example we will analyze the example from [8]:

```
DR <= 0
| DS <= 0: FS (130.0/1.0)
| DS > 0
| | ED <= 0: TR (2.0)
| | ED > 0: FS (9.0)
DR > 0
| DWE <= 0
| | ED <= 0
| | | DLS <= 0: FS (19.0/1.0)
| | | DLS > 0: TR (5.0)
| | ED > 0: TR (19.0)
| DWE > 0: TR (216.0/2.0)
Number of Leaves: 7
Size of the tree: 13
```

Rules extracted from Modified J48 decision tree;
R1: (DR=N, DS=N)=>(LD, N) (1)
R2: (DR=N, DS=Y, ED=N)=>(LD, Y) (2)
R3: (DR=N, DS=Y, ED=Y)=>(LD, N) (3)
R4: (DR=Y, DWE=N, ED=N, DLS=N)=>(LD, N) (4)
R5: (DR=Y, DWE=N, ED=Y)=>(LD, Y) (5)
R6: (DR=Y, DWE=N, ED=N, DLS=Y)=>(LD, Y) (6)
R7: (DR=Y, DWE=Y)=>(LD, Y) (7)

The rules have a term named confidence which is the likelihood of the detection outcome. Confidence can be the proof which shows that the prediction is valid.

This decision tree method is not the only way we can detect learning disabilities. One of the other way is using rough data set which is arranged manually. Initially, the rough data set is believed to be more accurate than decision tree method. However, the results show that the confidence of the rules from the decision tree give better results.

Table 3.2 Accuracy Comparison between J48 Algorithm and Rough Data Sets in Detecting Learning Disabilities[8]

Rules	Method	
	J48 Algorithm	Rough Data Sets
R1	95 %	80 %
R2	96 %	82 %
R3	95 %	80 %
R4	95 %	83 %
R5	94 %	85 %
R6	92 %	82 %
R7	93 %	-

From the results above, we understand that the decision tree method is really effective for prediction of LD. The population of LD in the world now is big enough.

According to National Institute of Health, one in seven Americans, has some type of LD. However, by using decision tree rules, we can easily detect the learning disabilities in children with great accuracy.

The basic idea behind the decision tree-learning algorithm is to test the most important attribute. First, by *most important* we mean the one that makes the most difference to the classification of an example. That way, we get to the correct classification with a small number of tests, meaning that all paths in the tree will be short and the tree as a whole will be small.

The main drawback notices from this study is that if the data is inconsistent, the decision all will be failure. And the formation of decision tree and the rules will become complex as the number if attributes increase.

IV. CONCLUSION

In this paper, we implement decision tree, the improvement of tree from discrete mathematics to keep learning disability database to detect sign and symptoms of learning disability in children. This paper mainly focuses on one approach. It is decision tree rule with J48 algorithm. The analysis of this problem using data that contain 16 attributes in the table and more than 100 real data sets with the attribute has been carried out through this study.

Decision tree with J48 algorithm is a powerful and effective tool to predict learning disabilities. J48 decision tree application on discrete data shows that it is better than rough data sets in terms of efficiency and complexity. J48 decision tree has to be applied on continuous or categorical data. So before using this method, it is really essential to learn and study about the noise effects and inconsistency of the data. And then , the results from the J48 decision tree have showed that it can generate simple rule and remove irrelevant attribute in processing of decision making. It would be good model of classification on small data sets.

Thus, the main point found in this method is it hasn't been successful for handling inconsistent data by itself. We need to check the inconsistency of data by ourselves.

In future, more research concerning detection of learning disabilities is required to apply the same approach for large data set and all relevant attributes together with its handle with inconsistent data.

V. APPENDIX

a) Node : the part of the tree that contain some information or value.
b) Edge : the connector of two nodes
c) Parent : node v is parent from node u if v and u is incident and v is at the level n-1 when u is at level n.
d) Child : if v is parent of u so u is child of v.
e) Binary search tree : binary tree that each right node has value more than left node.

VII. ACKNOWLEDGMENT

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PERNYATAAN

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Bandung, 7 Desember 2013

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