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The Possibility Prediction of Inheriting Blood Types in Parents Based on The Child's Allele Combination

Destya Aulia Nurul Hutami [a,1*], Afrizal Adi Nugroho [a,2], Aidha Salsa Billa [a,3], Reyhan Mochamad Fabian [a,4], Munawir [a,5], Muhammad Taufik Dwi Putra [a,6]

[a] Computer Engineering Study Program, Indonesian Education University, Cibiru Campus Jl. Education No. 15, Cibiru Wetan, District. Cileunyi, Bandung Regency, West Java 40625, Indonesia
[1] destyaanh@upi.edu *; [2] afrizaladin33@upi.edu; [3] aidhasalsabilla@upi.edu; [4] reyhan.3du@upi.edu; [5] munawir@upi.edu; [6] tdputra@upi.edu

* corresponding author

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ABSTRACT

The application of predicting the likelihood of blood group inheritance in children based on allele combinations from parents is becoming increasingly relevant. Understanding the combination of alleles that may appear in offspring can provide better insight for individuals and couples in planning families. The existence of an application to predict a child's blood type by using program development to form a family tree based on blood type can provide a clear visual picture of the inheritance of blood type from generation to generation. The purpose of this research is to identify allelic combinations of certain genes that affect a person's blood type and analyze how genetic inheritance occurs from parents to children. This study proves that we can see the likelihood of blood type inheritance of a child by looking at the allele combinations of both parents. This concept can be explained using the concept of a family tree (Tree). By using the Tree concept, we can easily visualize the inheritance of blood groups based on alleles, and facilitate the understanding of the formation of allele combinations that occur in the genetic inheritance process.

1. Introduction

The development of computer and information technology plays an important role in progress and solving problems in various fields, including in the field of education. In an educational context, the focus is often on learning problems. Each student has varying levels of ability in understanding the material, as is the case in Data Structure and Algorithm courses. This course is an important foundation for students of the Computer Engineering study program. However, the Data Structures and Algorithms course involves various basic programming concepts that must be understood, with a limited number of lecture meetings. This obstacle becomes a challenge for teachers to deliver all material by paying attention to the level of ability and understanding of each student. Therefore, a learning approach is needed that can support students so they can learn independently effectively [1].

Decision trees are used as a representation to model problems consisting of a series of decisions that lead to a solution. Each node in the tree represents a decision, while the leaves represent solutions. Schemes and decision tree structures are a modeling method based on graphic structures. Strategy in the decision-making process involves a comprehensive determination of all options that meet the outcome criteria in solving the problem. This approach is carried out sequentially using a decision tree representation. By utilizing this decision tree, the best method for calculating the probability of various conditions that may arise is carried out simultaneously by analyzing the factors that influence the decisions taken through the decision tree [2].

In the worldmedicine and genetics, knowledge of a person's blood type can provide important information, especially in the context of genetic inheritance from parent to child. Genetics is a science that studies the ins and outs of the inheritance of genetic traits from generation to generation. One of the genetic characteristics that can be inherited in genetic inheritance is blood type. The term blood group refers to a specific reaction that appears when testing antiserum against certain antigens from a blood group system. A person's blood type is determined by a combination of alleles of certain genes inherited from parents. Knowledge about blood type inheritance is not only useful for understanding family genetic dynamics, but also has implications in various areas of health, especially at the pregnancy planning stage [3].

The application of predicting the possibility of inheriting blood types in children based on the combination of alleles from parents is becoming increasingly relevant. Understanding the combination of alleles that are likely to appear in offspring can provide better insight for individuals and couples in planning their families. The existence of an application to predict a child's blood type by using program development to form a family tree based on blood type can provide a clear visual picture of the inheritance of blood types from generation to generation [4].

Information technology and advances in genetic analysis provide opportunities to develop predictive models that can provide useful and accurate information. It is hoped that the application of this technology can make a positive contribution in helping couples to make more informed decisions regarding family planning for a family [5].

the application predicts the possibility of inheriting blood types from parents based on the combination of alleles from the child, namely by analyzing knowledge about blood types in the context of genetic inheritance and its impact on family genetic dynamics. Exploring the implications of knowledge about blood type inheritance in the health sector, especially at the pregnancy planning stage. Identifying the combination of alleles of certain genes that influence a person's blood type and analyzing how genetic inheritance occurs from parent to child. Evaluating the relevance of predictive modeling applications to predict the probability of inheriting blood types in children based on the combination of alleles from parents. Develop a program or application to form a family tree based on blood type, with the aim of providing a clear visual picture of the inheritance of blood types from generation to generation. Explore opportunities for developing predictive models using information technology and genetic analysis to provide accurate and useful information to support informed decisions in family planning.

2. Literature Review

2.1. ABO System Blood Groups

One characteristic that can be inherited in humans is blood type. The ABO blood group system is one of the most clinically important blood groups.The ABO system blood group is determined based on the presence or absence of A or B antigens on red blood cells and A or B antibodies in plasma [6]. Blood components consist of erythrocytes (red blood cells), leukocytes (white blood cells), platelets (blood platelets), and plasma. CellWhite blood has an important role in the body's defense against infection and disease by producing antibodies to destroy harmful materials [7]. Karl Landsteiner's thinking about the ABO blood grouping system emphasizes the principle that antigens should not meet antibodies. If this happens, blood clots can occur which can result in impaired blood circulation and can be potentially fatal in patients receiving blood transfusions [8]. Each individual can have blood type A, B, AB, or O.

Blood type A generally has A antigens on red blood cells and B antibodies in blood plasma. Blood type B has B antigens on red blood cells and A antibodies in blood plasma. Blood type O does not have A and B antigens on red blood cells, but has A and B antibodies in blood plasma. Blood type AB has A and B antigens on red blood cells, but does not have A and B antibodies in blood plasma [9].

2.2. Application of Inheritance of Blood Type Characteristics Based on Mendel's Laws

The inheritance of blood group traits in humans can be explained by applying the laws of inheritance proposed by Gregor Mendel. The inheritance of blood groups is related to Mendel's first law which states:

"During the formation of gametes or daughter sex cells, the allele pairs of the two parent genes, which are a pair of alleles, will separate so that each gamete receives one allele from each parent" [10]. In Mendel's First Law,There is a pair of alleles that will undergo separation, and the offspring will receive one allele from each parent. This principle applies to various inherited traits, including blood type. There are two main systems that influence blood type: the ABO and Rhesus systems. This research will focus on the inheritance of blood groups in the ABO system. In the context of blood type, there are pairs of alleles that influence the phenotype and genotype. The ABO blood group system involves two main alleles, namely the A allele and the B allele which determine a person's blood type. Both alleles (A and B) are dominant, while the O allele is recessive [11].

The following is a table of combinations of three types of alleles.

Table 1. Blood type is a combination of three types of alleles

Blood group	Genotype	Gametes
A	IAIA/IAIO	IA, IO
B	IBIB/IBIO	IB, IO
AB	IAIB	IA, IB
O	IOIO	IO

2.3. Tree Data Structure

A tree, or tree, can be interpreted as a connected graph that does not have a circuit. As a non-linear data structure, a tree is described by a hierarchy between elements that are connected to each other hierarchically. This concept refers to the hierarchical relationship between elements in a tree data structure [12]. The tree data structure has various applications in basic operations in programming techniques, including search, predecessor, successor, minimum value, maximum value, insertion and deletion operations. Trees have many applications in programming and algorithms. Trees are often used to store and organize data hierarchically, such as directory structure representation in file systems, family relationship representation in genealogy, and data structure representation in computer programming [13].

3. Method

Research methods include data collection methods and development methods carried out. The data collection method used in this research is a literature review (Library Research). In this method, researchers collect theoretical data from books, research journals, and information sources from the internet that are relevant to the research topic, with the aim of gaining a solid understanding regarding the inheritance of blood types based on the combination of parental alleles. Furthermore, the program development method consists of several stages:

3.1. Object Selection

Conduct observations and literature studies to determine the research topic, so that the idea of the research object emerges, namely the inheritance of the ABO blood group system in children.

3.2. Identification of problems

Analyze and understand the application of inheritance of blood group traits based on Mendel's laws.

3.3. Analysis

Analyze and understand the application of inheritance of blood group traits based on Mendel's laws.

3.4. Program design

Designing the program to be built, starting from program workflow design to appearance, and involves the program coding stage.

3.5. Implementation

Testing the program by implementing the algorithm method that has been created, using the Tree data structure, into the programming language. By aligning data collection methods and program development methods, this research can systematically understand and overcome problems related to blood group inheritance

4. Results and Discussion

This research obtains a Tree concept from the formation of possible inheritance of blood types based on the combination of alleles from parents.

Table 2. Combination of A, B and O alleles

Combination	A	B	O
A	AA, AO, AB	AB, AO, AA, BB, BO	AO, AA, OO, BO, AB
B	AB, BB, BO, AO, AA	BB, BO, AB	BO, AO, AB, BB, OO
O	AO, AA, OO, BO, AB	BO, AO, AB, BB, OO	OO, AO, BO

It can be seen in the table that if a child has the same alleles, 3 combinations of alleles will form, while for unequal alleles, 5 combinations will be formed. For example, if a child has the AA allele, then the possible alleles from both parents are AA, AO, AB. If a child has the AB allele, then the possible alleles from both parents are AA, BB, AB, AO, BO.

This combination is formed from the ABO system for determining blood groups based on alleles, which can be seen in the picture below.

Golongan	Genotif	Gamet
A	I^AI^A / I^AI^O	I^A, I^O
B	I^BI^B / I^BI^O	I^B, I^O
AB	I^AI^B	I^A, I^B
O	I^OI^O	I^O

Fig. 1. ABO system for determining blood groups. *(source: Integrated Basic Biology Book[14])*

This proves that the combination in the table above is correct, namely blood type A has the possibility of alleles. Likewise with other blood types.I^A, I^O

After knowing the formation of the allele combination, the implementation was carried out in a C++ program, the code of which can be seen below.

```
#include <iostream>
#include <vector>
#include <string>
```

```
#include <cstdlib>
#include <ctime>

using namespace std;

struct ParentPair {
string parent1;
string parent2;

ParentPair(string p1, string p2) : parent1(p1), parent2(p2) {}
};

vector<ParentPair> findParentAlleles(string child) {
vector<ParentPair> possibleParents;
vector<string> alleles = {"A", "B", "O"};
for (const string& p1_allele1 : alleles) {
for (const string& p1_allele2 : alleles) {
string parent1 = p1_allele1 + p1_allele2;
for (const string& p2_allele1 : alleles) {
for (const string& p2_allele2 : alleles) {
string parent2 = p2_allele1 + p2_allele2;
vector<string> possibleChildren = {
string(1, parent1[0]) + parent2[0],
string(1, parent1[0]) + parent2[1],
string(1, parent1[1]) + parent2[0],
string(1, parent1[1]) + parent2[1]
};
for (const string& combination : possibleChildren) {
if (combination == child || (combination[1] == child[0] && combination[0] ==
child[1])) {
possibleParents.push_back(ParentPair(parent1, parent2));
break;
}
}
}
}
}
}
return possibleParents;
}

void displayBloodType(const string& label, const string& bloodType) {
cout << label << ": blood type " << bloodType << endl;
}

int main() {
string child;
cout << "Enter the child's alleles (eg, BO): ";
cin >> child;
if (child.length() != 2) {
cout << "Invalid input format. Please enter two characters for the alleles, eg,
BO, AB, etc." << endl;
return 1;
}
vector<ParentPair> parents = findParentAlleles(child);
if (parents.empty()) {
cout << "No parent allele combination matches the child's alleles." << endl;
} else {
srand(time(0));
int randomIndex = rand() % parents.size();
ParentPair randomParentPair = parents[randomIndex];
displayBloodType("Child", child);
displayBloodType(" Parent (Father/Mother)", randomParentPair.parent1);
displayBloodType(" Parent (Father/Mother)", randomParentPair.parent2);
}
```

```
return 0;
}
```

When run, the program will ask for input of alleles in the child in combinations A, B and O.

Fig. 2. User input from the program being run

The output of the program below.

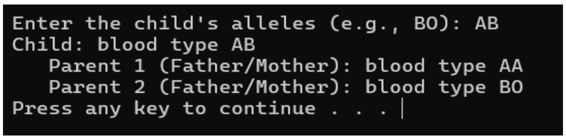

Fig. 3. Output Program

In the program above, different input is given, however, the results show the possibility that the alleles in both parents have a different combination than in the previous program. This happens because the algorithm applied to the program makes the output dynamic.

If this algorithm is made in diagram form, the results will be as in the image below.

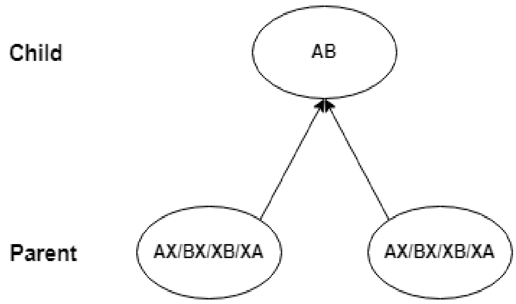

Fig. 4. Diagram of the program algorithm briefly

The result of the genetic combination of both parents will contain at least one allele that is the same as that of the child, while the other allele can be a different allele. In the figure, the different alleles are represented as allele "X", which can be A, B, or O.

There is a situation that is impossible for parents who have a child with the AB allele. Look at the following diagram image.

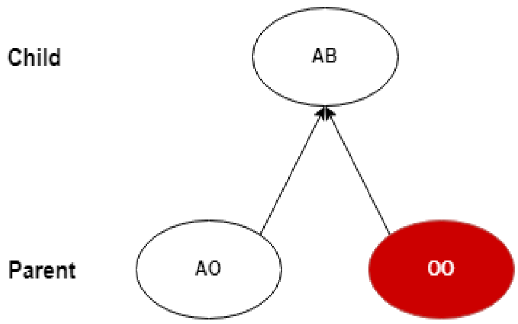

Fig. 5. Diagram of an unlikely case on parental alleles

Pay attention to the diagram marked in red. In cases where one of the parents has the "AB" allele in the child, it is impossible for that parent to have the "OO" allele, because the child has inherited the "AB" allele combination. Therefore, at least one of the parents must have at least one allele in common with the child, in which case, that parent may not be the child's biological parent.

5. Conclusion

This research not only reveals the Tree concept of forming possible inheritance of blood groups based on the combination of alleles from parents, but also provides insight into the structure of DNA data and the algorithms used in the analysis process. Through the implementation of a dynamic C++ program, where the output of possible alleles in both parents can vary according to the given input, providing a better understanding of how the algorithm can adapt to different conditions. An important thing highlighted in the results and discussion is the existence of impossible cases, where the child has different alleles to one or both parents. However, this study highlights the possibility that children with these alleles may not be their biological parents, adding complexity to the analysis of genetic inheritance. Thus, this research not only provides a better understanding of blood group inheritance mechanisms, but also provides important insights into DNA data structures and algorithms that can adapt to different conditions. This can provide a solid basis for further developments in the field of genetics and genetic data analysis.

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