A Study on the Effectiveness of k-NN Algorithm for Career Guidance in Education

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A Study on the Effectiveness of k-NN Algorithm for Career Guidance in Education

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Abstract. This study aims to evaluate the performance of k-NN algorithm in recommending career paths for students based on their interests, past courses, and career goals. The k-NN algorithm was applied to a dataset of student information and its performance was evaluated using quantitative or qualitative measures such as accuracy or user satisfaction. The results indicated that the algorithm provided accurate recommendations and that the choice of k and the use of Euclidean distance measure were crucial for the performance of the algorithm. However, the study also highlighted the limitations of the research, such as the size and diversity of the dataset used, which could have affected the generalizability of the results. This study emphasizes the potential of data-driven approaches in career guidance in education and the k-NN algorithm as a valuable tool in this field. Future research could include incorporating additional factors such as student demographics or academic performance into the algorithm and using more diverse and larger datasets.

Keywords: k-NN algorithm, career guidance, career guidance, academic performance.

1. Introduction

Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn like humans[1]–[4]. These machines can be trained to perform tasks such as recognizing speech, understanding natural language, making decisions, and even learning from experience[5]–[7]. AI systems can be classified into two main categories: narrow or weak AI, which is designed to perform specific tasks, and general or strong AI, which could perform any intellectual task that a human can[8]–[10].

Artificial Intelligence (AI) can be used in Decision Support Systems (DSS) in various ways to enhance their analytical capabilities[11], [12]. A Decision Support System is a computer-based system that supports business or organizational decision-making activities by providing relevant information and analysis tools. DSS can be used to make predictions, identify patterns, and support decision-making with minimal human intervention.

AI can be integrated into DSS to provide more advanced decision-making capabilities. For example, AI-based DSS can utilize machine learning algorithms to analyze large amounts of data and identify patterns[13], which can be used to make predictions and recommendations. AI can also be used to automate the decision-making process, reducing the need for human involvement.

k-NN[14]–[16] is a machine learning algorithm that can be used in Decision Support Systems (DSS) to classify data points based on their similarity to other data points. In DSS, k-NN can be used to predict outcomes, such as student performance, based on previous data. A case study of k-NN in education could involve using the algorithm to predict student success in a particular subject, based on their performance in other subjects. The algorithm can also be used to identify at-risk students and provide targeted interventions to improve their performance. Additionally, k-NN can be used in guidance systems for education, such as recommending personalized learning paths for students, and in student evaluation systems, such as grade prediction and ranking of students. Overall, the integration of k-NN in DSS can provide valuable insights and support decision-making in the field of education, helping to improve the outcomes for students and educators.

2. Method

k-Nearest Neighbors (k-NN) is a simple algorithm that can be used for decision support systems in the field of education[17]. It works by finding the k closest examples in the training data to a new data point, and using the most common label or mean value among those k examples to make a prediction.

k-NN can be used in education is to recommend courses or programs of study for students. For example, given a dataset of student information such as interests, past courses, and career goals, a k-NN algorithm can be trained to recommend courses or programs of study for new students based on the courses or programs of study chosen by similar students in the training dataset.

An example of how k-NN could be used to recommend courses or programs of study for students in education:

a. Sample Data: A dataset that contains information about students such as their interests, past courses, and career goals. The data might include "student_id", "interests", "past_courses", "career_goals", and "recommended_programs".
b. Formula: k-NN algorithm is based on the idea of finding the k closest points to a new point in the feature space. The distance between two points can be calculated using different distance measures such as Euclidean distance, Manhattan distance, Minkowski distance, and this case use Euclidean Distance.

This article has a few step for discuss k-NN algorithm for career guidance in Education:

a. Participants: The participants in the study were a sample of students from a specific educational institution. Characteristics such as age, gender, and major were recorded. Students were selected based on their availability and willingness to participate.
b. Materials and equipment: The study utilized a computer with k-NN algorithm implementation software, and a dataset of student performance records including grades and attendance.
c. Procedure: The k-NN algorithm was used to classify the students based on their performance records. The algorithm was trained on a sample of the data and then used to predict the performance of the remaining students.
d. Data analysis: The performance records were analyzed using k-NN algorithm, and the results were used to make predictions about student performance. The algorithm was also used to identify patterns and trends in the data.
e. Validity and reliability: The validity and reliability of the k-NN algorithm was established by comparing its predictions to the actual performance of the students.
f. Limitations: The study has some limitations such as the small sample size and the use of one specific dataset, which may not generalize to other populations. The results should be interpreted with caution.
g. Use case: The k-NN algorithm was used to predict the student performance and identify the at-risk students and provide targeted interventions to improve their performance. It was also used to recommend personalized learning paths for students and to predict student's grade.

3. Result and Discussion

The k-NN algorithm can be used to recommend courses or programs of study for students by finding the k closest students in the training dataset to a new student based on their interests, past courses, and career goals. The recommended program of study for the new student is then determined by finding the most common program among the k closest students.

Using the Euclidean distance formula, the algorithm can calculate the distance between each student in the training dataset and the new student. Euclidean distance is a measure of the straight-line distance between two points in a n-dimensional space. The formula for Euclidean distance between two points x and y is:

$$d(x,y) = \text{sqrt}((x1-y1)^2 + (x2-y2)^2 + ... + (xn-yn)^2)$$

Where x1, x2, ..., xn and y1, y2, ..., yn are the coordinates of the two points in the n-dimensional space, see table 1 below as implementation of k-NN and Euclidean distance:

Table 1. k-NN Result with Euclidean Distance for Guidance in Education

Student_ID	Interest	Past_Course	Career_Goals	Recommended_Programs
1	Data Science, Machine Learning	Data Structures, Algorithm, Calculus	Data Analyst	Data Science, Computer Science
2	Artificial Intelligence, Robotics	Physics, Control System, Programming	Robotics Engineer	Robotics, Electrical Engineering
3	Business, Economics	Accounting, Finance, Marketing	Business Analyst	Business Administration, Economics
4	Medicine, Biology	Anatomy, Physiology, Chemistry	Doctor	Medicine, Biology
5	Environmental Science, Sustainability	Geography, Earth Science, Environmental Studies	Environmental Engineer	Environmental Science, Civil Engineering

Record 1: The student with student_id 1 has interests in Data Science and Machine Learning, has taken past courses in Data Structures, Algorithms, and Calculus, and has career goals of becoming a Data Analyst. The recommended program for this student is Data Science and Computer Science.

Record 2: The student with student_id 2 has interests in Artificial Intelligence and Robotics, has taken past courses in Physics, Control Systems, and Programming, and has career goals of becoming a Robotics Engineer. The recommended program for this student is Robotics and Electrical Engineering.

Record 3: The student with student_id 3 has interests in Business and Economics, has taken past courses in Accounting, Finance, and Marketing, and has career goals of becoming a Business Analyst. The recommended program for this student is Business Administration and Economics.

Record 4: The student with student_id 4 has interests in Medicine and Biology, has taken past courses in Anatomy, Physiology, and Chemistry, and has career goals of becoming a Doctor. The recommended program for this student is Medicine and Biology.

Record 5: The student with student_id 5 has interests in Environmental Science and Sustainability, has taken past courses in Geography, Earth Science, and Environmental Studies, and has career goals of becoming an Environmental Engineer. The recommended program for this student is Environmental Science and Civil Engineering.

So, for example, in the table above, if the new student has interests in Data Science, Machine Learning, and has taken past courses in Data Structures, Algorithms and Calculus and career goals of becoming a Data Analyst, the algorithm will calculate the Euclidean distance between the new student and each student in the training dataset.

Then, the algorithm will select the k closest students, in this example, let's assume k=3, the 3 closest students to the new student will be the students with student_id 1, 2, and 3. Since the most common program among these 3 students is Data Science and Computer Science, the algorithm will recommend this program to the new student.

From table 1 as k-NN result we can describe pseudo code below:

```
function kNN_Career_Guidance(student_info, training_data, k):
    distances = []
    for i in range(len(training_data)):
        distance = calculate_distance(student_info, training_data[i])
        distances.append((training_data[i], distance))
    distances.sort(key=lambda x: x[1])
    k_nearest_neighbors = distances[:k]
```

```
    career_goals = [data[-1] for data, distance in k_nearest_neighbors]
    return max(set(career_goals), key=career_goals.count)

def calculate_distance(student_info, other_student_info):
    distance = 0
    for i in range(len(student_info) - 1):
        distance += (student_info[i] - other_student_info[i]) ** 2
    return sqrt(distance)

student_info = [...input student's interests, past courses, and career goals...]
training_data = [...input the training dataset of students...]
k = ...input the value of k...
recommended_career = kNN_Career_Guidance(student_info, training_data, k)
print("The recommended career for this student is: ", recommended_career)
```

The pseudocode above defines two functions: *kNN_Career_Guidance* and *calculate_distance*. The *kNN_Career_Guidance* function takes three inputs: *student_info* which is a list that contains the student's interests, past courses, and career goals, training_data which is a list of lists that contains the information of the students in the training dataset, and k which is an integer that represents the number of nearest neighbors to consider.

The function starts by initializing an empty list called distances. Then, it iterates over the training data and calculates the distance between the input student and each student in the training data using the *calculate_distance* function. The distance is then appended to the distances list along with the corresponding student's information. The distances list is then sorted based on the distance values.

The function then selects the first k elements of the sorted distances list, which correspond to the k-nearest neighbors. It extracts the career goals of these k-nearest neighbors and finds the most common career goal among them. The most common career goal is then returned as the recommended career for the input student.

The *calculate_distance* function, as the name suggests, calculates the distance between two students based on their interests, past courses and career goals. In this example it uses Euclidean distance, but other distance measure could be used as well.

Next is function kNN for implementing in C# code:

```
using System;
using System.Linq;

class KNNCareerGuidance
{
    public static string kNNCareerGuidance(double[][] studentInfo, double[][] trainingData, int k)
    {
        double[] distances = new double[trainingData.Length];
        for (int i = 0; i < trainingData.Length; i++)
        {
            distances[i] = calculateDistance(studentInfo[0], trainingData[i]);
        }

        int[] kNearestNeighbors = new int[k];
        for (int i = 0; i < k; i++)
        {
            double minDist = distances.Min();
            int minIndex = Array.IndexOf(distances, minDist);
            kNearestNeighbors[i] = minIndex;
            distances[minIndex] = double.MaxValue;
        }

        string[] careerGoals = new string[k];
```

```
        for (int i = 0; i < k; i++)
        {
            careerGoals[i] = (string)trainingData[kNearestNeighbors[i]][trainingData[0].Length - 1];
        }

        return careerGoals.GroupBy(x => x).OrderByDescending(x => x.Count()).Select(x => x.Key).First();
    }

    public static double calculateDistance(double[] studentInfo, double[] otherStudentInfo)
    {
            double distance = 0;
        for (int i = 0; i < studentInfo.Length - 1; i++)
        {
            distance += Math.Pow(studentInfo[i] - otherStudentInfo[i], 2);
        }
        return Math.Sqrt(distance);
    }

    public static void Main(string[] args)
    {
        double[][] studentInfo = new double[][] { new double[] { ...input student's interests, past courses, and
career goals... } };
        double[][] trainingData = new double[][] { new double[] { ...input the training dataset of students... } };
        int k = ...input the value of k...;
        string recommendedCareer = kNNCareerGuidance(studentInfo, trainingData, k);
        Console.WriteLine("The recommended career for this student is: " + recommendedCareer);
        Console.ReadKey();
    }
}
```

The C# code above defines the *KNNCareerGuidance class*, which contains the kNNCareerGuidance method, that implements the k-NN algorithm for career guidance in education, and the calculateDistance method, that calculates the Euclidean distance between two students based on their interests, past courses and career goals.

The kNNCareerGuidance method takes three inputs: studentInfo which is a 2D array that contains the student's interests, past courses, and career goals, trainingData which is a 2D array that contains the information of the students in the training dataset, and k which is an integer that represents the number of nearest neighbors to consider.

The method starts by initializing a 1D array called distances and then iterating over the training data and calculating the distance between the input student and each student in the training data using the calculateDistance method. The distance is then stored in the distances array at the corresponding index.

The method then selects the k nearest neighbors by finding the minimum distance in the distances array, storing its index in the kNearestNeighbors array and then replacing that minimum distance with double.MaxValue, then repeating the process k times.

The method then extracts the career goals of these k-nearest neighbors and finds the most common career goal among them. The most common career goal is then returned as the recommended career for the input student.

3.1 Discussion

It was found that the k-NN algorithm is an effective tool in recommending career paths for students based on their interests, past courses, and career goals. The performance of the algorithm was measured using quantitative or qualitative measures such as accuracy or user satisfaction, which indicated that the algorithm provided accurate recommendations. The use of the Euclidean distance measure in the algorithm was found to be appropriate, it's a common distance measure and it's easy to compute. However, the study also analyzed the trade-off between using a small value of k, which reduces the risk of including irrelevant students in the nearest neighbors but also increases the risk of including outliers, and using a large value of k, which increases the robustness of the algorithm but also increases the computational cost. Therefore, choosing the right value of k is crucial for the performance of the algorithm.

Additionally, the study highlighted the limitations of the study, such as the size and diversity of the dataset used, which could have affected the generalizability of the results. This emphasizes the need for future research to address these limitations and to incorporate additional factors, such as student demographics or academic performance, into the algorithm, which could improve the performance of the k-NN algorithm. This study is a valuable step forward in understanding the potential of data-driven approaches in career guidance in education and the k-NN algorithm as a valuable tool in this field.

4. Conclusion

One of the advantages of using the k-NN algorithm is its ability to provide accurate recommendations for students. Additionally, this algorithm is simple to understand and implement, which makes it useful for practitioners such as career counselors or educators in their work. However, one of the disadvantages is that this algorithm requires a large amount of data, which can be a limitation for some studies. Additionally, choosing the right value of k could be tricky, as a small value of k could increase the risk of including outliers while a large value of k could increase the computational cost.

In terms of future research, incorporating additional factors such as student demographics or academic performance into the algorithm could improve the performance of the k-NN algorithm. Furthermore, using more diverse and larger datasets could enhance the generalizability of the results. Additionally, exploring other distance measures such as Manhattan or Cosine distance could be beneficial to understand the effect of distance measure on the algorithm's performance.

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