Automated detection of various types of plagiarism in academic papers of IT students

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Abstract

The article explores the problem of automated detection of various types of plagiarism in academic works of IT students. Particular attention is paid to the more challenging forms of plagiarism to detect, especially those based on paraphrasing. An experiment was conducted using five popular plagiarism detection services. For analysis, a dataset was compiled consisting of 50 original texts and 712 paraphrased versions. A metric called Paraphrasing Detection Sensitivity (PDS) is proposed to quantitatively assess the ability of the services to identify paraphrasing plagiarism. The results revealed a significant variation in effectiveness among the systems, and conclusions were drawn regarding their practical applicability.

Keywords

plagiarism, paraphrasing plagiarism, automated processes, paraphrasing detection sensitivity metric, ethical academic practices, academic originality assessment, future IT Professionals, vocational skill development, automated processes, digital rights law, AI-powered information systems

1. Introduction

Information technologies play a key role in organizing labor, education, research, entertainment, and other aspects of everyday human activity [1, 2, 3]. They serve as a driving force that shapes the economic, technological, and scientific potential of a country.

In this regard, it is important to train future IT specialists, as they play an important role in the process of setting up and maintaining computer systems, participate in the development and further support of software, and influence the level of development and penetration of information technology in all spheres of human life [4, 5]. After graduation, future IT specialists should have a system of professional and key competencies, be ready to work in a team, have skills of self-learning, self-organisation and continuous professional growth.

The development of digital technologies, in addition to its obvious positive effects [6, 7], has negative aspects. With the development of digital technologies, students have gained wide access to information resources. This, on the one hand, increases the efficiency of the learning process, and on the other hand, creates preconditions for unauthorised copying of other people's materials without proper acknowledgement. This practice undermines academic integrity, distorts assessment results and negatively affects the quality of training of future professionals. Therefore, detecting and preventing plagiarism is

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an important task for higher education institutions that requires effective solutions, in particular by automating the verification process.

The problem of automating the detection of plagiarism in student papers is not new. In particular, Durge et al. [8] describe the peculiarities of using the developed computer system for detecting plagiarism in computer programming. Gambo et al. [9] describe the GRAD-AI software tool, an automated tool for assessing computer programming assignments that combines automation with teacher involvement for accurate grading, timely feedback, and personalised support, enhancing the educational process. Sağlam et al. [10] proves the importance of human involvement in the process of automatic plagiarism detection. This paper presents a novel approach for automated plagiarism detection in modeling assignments that combines automated analysis with human inspection. The results show that we achieve a significantly higher detection rate for AI-generated attacks and a broader resilience than the state-of-the-art.

In recent years, humanity has been actively using artificial intelligence systems [11, 12, 13, 14, 15, 16], in particular generative artificial intelligence [17], to meet its daily needs. The educational process is no exception. The absence of ethical principles in generative AI and the ability of people to use it for their own benefit quite easily contribute to the use and abuse of AI-based tools by students of higher education institutions. Therefore, every year there is an increasing number of works devoted to the ethical aspects of using AI in the educational process. Among these works, it is worth highlighting papers [18, 19, 20].

Our study focuses on automating the process of detecting different types of plagiarism in the works of IT students. Therefore, it was important for our study to consider the types of academic plagiarism. Based on the analysis of works [21, 22], the following types of plagiarism were identified: complete plagiarism, direct plagiarism, accidental plagiarism, plagiarising yourself, paraphrasing plagiarism, source-based plagiarism, mosaic plagiarism, AI plagiarism.

This is not the first time that the authors of this article have studied the problem of detecting plagiarism in student papers. Thus, in [23], the authors investigated the peculiarities of using artificial intelligence systems to assess the complexity of an algorithm based on student code fragments. In [22], the authors developed a software application to automate the routine work of university professors in checking student papers for plagiarism and detecting it with the help of AI. The developed software application uses various APIs to search for plagiarism and fragments of text/code generated by AI.

The purpose of this study is to determine the effectiveness of existing automatic plagiarism detection systems in recognising different types of plagiarism in the works of IT students.

2. Methodology

Let us take a closer look at the types of plagiarism and the possibilities of their automatic detection. It is evident that complete plagiarism and direct plagiarism are the easiest types to detect using automated tools. In the case of complete plagiarism, a student or author entirely copies someone else's work without making any changes, whereas direct plagiarism involves verbatim reproduction of individual text fragments without proper citation.

Accidental plagiarism occurs when a student unknowingly presents someone else's ideas, text or code as their own due to a lack of knowledge about proper citation, poor paraphrasing skills or a misunderstanding of what exactly constitutes plagiarism. From the point of view of automatic detection, unintentional plagiarism is a separate issue. Typical checking systems may flag such cases in the same way as intentional plagiarism, without taking into account the author's intent, as such systems evaluate the result, not the process.

From a technical point of view, detecting self-plagiarism is no different from detecting direct plagiarism, as both cases involve finding textual or structural similarities between documents. However, the key difference lies in the source of comparison: to detect self-plagiarism, it is needed to have access to the student's historical work, including previously submitted term papers, labs or projects. Thus, effective detection of self-plagiarism is only possible if the algorithm can compare the new work not only with open sources, but also with the local internal archive of the educational institution.

Source-based plagiarism is a type of academic dishonesty in which a student misuses or intentionally distorts sources. Such plagiarism does not necessarily involve copying text, but rather manipulating references.

AI plagiarism is a type of plagiarism when a student submits as his or her own work text or code generated in whole or in part by artificial intelligence systems. Although such materials may be formally "unique" from the point of view of classical plagiarism detection systems, they are not the product of independent intellectual activity, which contradicts the principles of academic integrity. The main difficulty lies in the fact that AI-generated text may not have any matches with public sources, so automatic verification tools may not detect violations. In [22], the authors conclude that none of the services demonstrate good results in detecting AI plagiarism.

A special place among the types of plagiarism is occupied by paraphrasing plagiarism and mosaic plagiarism. Paraphrasing occurs when a student rewrites someone else's text in his or her own words, preserving the main idea, structure, and content without proper reference to the source. Mosaic plagiarism is the creation of a text by collecting fragments from different sources with partial paraphrasing, changing grammatical structures, or replacing words with synonyms without proper citation. From the point of view of automatic detection, these types of plagiarism are much more difficult to identify than verbatim copying. This requires algorithms that take into account not only superficial but also semantic similarities between texts.

Studies show that paraphrasing is a common practice among students and, in some cases, even their primary strategy. At the same time, students tend to avoid deep comprehension of the original text, favoring superficial or mechanical paraphrasing, also known as patchwriting [24].

That is why in our work we paid attention to determining the quality of automatic paraphrasing detection. As part of the study, we conducted an experiment using a number of automated plagiarism detection services. We are not interested in the generalised quality of the services, but rather in the difference between their ability to detect complete plagiarism and direct plagiarism and their ability to detect paraphrasing plagiarism.

Two sets of textual data were prepared as part of the study. The first set (named TO (1)) contained fragments of student papers (term papers, bachelor's and master's theses) published on the Internet. Since these texts are publicly available, plagiarism detectors should recognise them as cases of direct plagiarism with a complete or almost complete match.

$$\text{TO} = \{\text{to}_i | i = 1 \dots n\} \tag{1}$$

where TO is a set of original (published) student texts, to_i is an i-th text from TO set, $i = 1, \dots, n$, and n is the total number of texts in this set.

For further comparative analysis, a set of sets (named TP (2)) of paraphrased versions was created for each text from the first set. Some of them were generated using artificial intelligence tools, while others were paraphrased manually.

$$\begin{gathered} \text{TP} = \{\{\text{tp}_{ij} | j = 1 \dots k_i\} | i = 1 \dots n\} \\ \text{TP} = \{\text{TP}_i | i = 1 \dots n\} \end{gathered} \tag{2}$$

where TP is a set of sets of paraphrased versions of student texts, k_i is a number of paraphrased versions for text to_i, $i = 1, \dots, n$, tp_{ij} is a j-th paraphrased version of text to_i, $i = 1, \dots, n$, $i = j, \dots, k_i$.

Thus, each original text $\text{to}_i \in \text{TO}$ corresponds to a subset TP_i:

$$\text{TP}_i = \{\text{tp}_{ij} | j = 1 \dots k_i\} \tag{3}$$

The result of the to_i text plagiarism detection will be a certain value $\text{R}(\text{to}_i) \in [0 \dots 1]$. The same applies to the values $\text{R}(\text{tp}_{ij}) \in [0 \dots 1]$, which are the results of the plagiarism detection for texts tp_{ij}. A value of 0 means that no plagiarism has been detected, and a value of 1 means that the entire text is plagiarised. An ideal plagiarism detector would return a value of 1 for all texts that participate in the experiment.

To evaluate the quality of the paraphrasing plagiarism detection, we offer a metric of sensitivity to paraphrasing – paraphrasing determination sensitivity (PDS):

$$PDS = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{k_i}\sum_{j=1}^{k_i}|R(\text{to}_i) - R(\text{tp}_{ij})| \quad (4)$$

From expression (4), it follows that PDS is also a normalised value, i.e. it falls within the interval [0...1]. A low PDS value means that the service responds almost equally to original and paraphrased texts (a value of 0 means that the response is the same). A high PDS value means that the service is much better at detecting complete plagiarism and direct plagiarism than paraphrasing plagiarism.

3. Results and discussion

We reviewed 37 plagiarism detection services. Among the available services, we chose those that demonstrate good results in detecting complete plagiarism and direct plagiarism, as there is no point in checking texts for paraphrasing plagiarism in cases where even basic forms of plagiarism are not detected effectively. The list of such services is as follows:

1. Paraphraser plagiarism checker [25].
2. Desklib plagiarism checker [26].
3. Plagiarism Checker by JustDone [27].
4. 1text.com Plagiarism Checker [28].
5. Smart Plagiarism Checker by ExpertChat AI [29].

As part of the experiment, we selected 50 original student works (bachelor's and master's theses, course projects) that are publicly available. These student papers form the TO set ($n = 50$).

To generate the paraphrased texts, the authors used both artificial intelligence tools (with prior verification of the generated output) and manually created texts. For each original text, between 9 and 20 paraphrased versions were produced ($9 \leq k_i \leq 20$). The total number of paraphrased texts is 712.

As an example, table 1 presents the values obtained by running all the services on one of the original texts, along with the results for its paraphrased versions. The values are expressed as percentages.

Table 1
Example of plagiarism check results for one of the texts and its paraphrases.

Services	to_1	$\text{tp}_{1,1}$	$\text{tp}_{1,2}$	$\text{tp}_{1,3}$	$\text{tp}_{1,4}$	$\text{tp}_{1,5}$	$\text{tp}_{1,6}$	$\text{tp}_{1,7}$	$\text{tp}_{1,8}$	$\text{tp}_{1,9}$	$\text{tp}_{1,10}$
Paraphraser	75	44	50	33	50	46	53	37	33	50	61
Desklib	68	0	25	0	22	30	11	0	0	0	24
JustDone	91	80	77	75	84	75	83	66	67	85	91
1text.com	81	0	0	0	0	0	0	0	0	0	0
ExpertChat	87	84	88	85	86	80	85	77	79	88	90

If only one of the above original texts had been used in the experiment, the values of the paraphrasing sensitivity metrics for each of the services would have been the same as those shown in table 2.

As a result of performing the verification procedure for each of the test texts from the TO and TP sets using each of the plagiarism detection services, a data set was obtained, on the basis of which the sensitivity of each of the studied services to paraphrased texts was calculated. This allows for a comparative analysis of their effectiveness. These results are presented in table 3.

The results show a significant difference between different services in terms of sensitivity to paraphrasing. The PDS values for ExpertChat and JustDone are close to 0, which means that they provide high-quality verification of paraphrased texts. The services from 1text.com and Desklib demonstrate good results only for direct plagiarism, but they are unable to recognise plagiarism in paraphrased texts.

Table 2
A set of PDS values to paraphrasing for one of the original texts.

Services	PDS
Paraphraser	0.293
Desklib	0.568
JustDone	0.127
1text.com	0.810
ExpertChat	0.038

Table 3
A set of PDS values for services.

Services	PDS
Paraphraser	0.288
Desklib	0.541
JustDone	0.124
1text.com	0.782
ExpertChat	0.043

The Paraphraser service identifies a significant percentage of paraphrased text and can therefore be used as a support mechanism.

The total number of texts for which the plagiarism checking procedure was executed is calculated in expression (5):

$$m = n + \sum_{i=1}^{n} k_i = 762 \tag{5}$$

This exceeds the minimum sample size required ($n \approx 384$) to estimate proportions with a 95% confidence level and a margin of error of $\pm 5\%$. Accordingly, the obtained sensitivity values can be considered statistically reliable with an error of no more than $\pm 3.7\%$. In addition, since all the texts in the study belong to the IT industry, this ensures high internal homogeneity of the data.

4. Conclusion

This study conducted a comprehensive analysis of the effectiveness of modern services for the automatic detection of plagiarism in student texts in IT. Particular attention is paid to the forms of plagiarism that are difficult to detect, such as paraphrasing.

An experimental dataset was created, consisting of 50 original texts and 712 paraphrased versions. Each text was checked using five popular plagiarism detection services.

In order to quantify the ability of services to recognise paraphrasing plagiarism, the PDS (paraphrasing detection sensitivity) metric was proposed. The results of calculating this metric showed a significant difference in sensitivity between different systems and confirmed the limited ability of most tools to detect plagiarism in transformed texts.

In the future, it is planned to investigate how the type of paraphrasing (lexical, syntactic, semantic or pattern) affects the effectiveness of plagiarism detection. Such an analysis will help identify weaknesses in the work of existing services and formulate recommendations for their improvement.

Declaration on Generative AI

The authors have not employed any generative AI tools.

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