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Xiao Feiyu

DISTORTED QR CODE CORRECTION ALGORITHM

ABSTRACT
for a master's degree

Speciality 1-40 80 02 System analysis, information control and processing
(by industries)

Academic Supervisor
German Oleg Vitoldovich
Candidate of Technical Sciences,
Associate Professor of the
Department of ITAS, BSUIR

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INTRODUCTION

The topic of the dissertation work corresponds to the list of priority areas determined by the Decree of the President of the Republic of Belarus dated September 15, 2021 No. 348.

The thesis focuses on the development of a distorted QR code correction algorithm using Hamming codes within the field of digital information and communication technologies. QR codes have become ubiquitous in various domains, serving as a popular means of storing and transmitting information. However, due to factors such as print errors, image degradation, and environmental interference, QR codes can become distorted, resulting in decoding errors and rendering them unreadable. Therefore, the correction of distorted QR codes is of the most significance to ensure accurate information retrieval and seamless user experience.

In the realm of error correction codes, Hamming codes have been extensively studied and widely employed in various applications. Hamming codes provide a powerful mechanism for error detection and correction, making them well-suited for addressing errors caused by distortion in QR codes. By employing Hamming codes, the proposed algorithm aims to detect and correct errors introduced during the encoding and printing process, thereby enhancing the reliability and robustness of distorted QR codes.

While Hamming codes form the core of the proposed algorithm, it is essential to consider the insights gained from existing works that pertain to related concepts. Several studies have explored the application of Reed-Solomon codes in error correction, particularly for data storage and communication systems. Reed-Solomon and BCH codes exhibit strong error correction capabilities and have been successfully employed in barcode technologies.

In addition to error correction codes, the algorithm may also benefit from the utilization of affine transformations and inverse transformation method. By incorporating appropriate affine transformations, the proposed algorithm can rectify and align distorted QR codes, facilitating subsequent decoding and error correction processes, also image process.

The significance of the dissertation lies in its objective of addressing the challenges associated with distorted QR codes through the utilization of Hamming codes. The successful development of a distorted QR code correction algorithm using Hamming codes will contribute to enhancing the usability and effectiveness of QR codes in various applications, ranging from marketing campaigns to supply chain management.

GENERAL DESCRIPTION OF THE WORK

Relevance of the subject

The dissertation research was carried out within the framework of the direction “Digital information and communication and interdisciplinary technologies, production based on them” on the realization and implementation of hardware and software solutions using artificial intelligence, big data bases for the Internet of things, industrial Internet, cloud technologies, intelligent electronic terminals in accordance with the State Program for Innovative Development of the Republic of Belarus for 2021–2025, approved by Decree of the President of the Republic of Belarus dated September 15, 2021 No. 348.

The aim and tasks of the work

The aim of this work is to develop a distorted QR code correction algorithm. To achieve this aim, the following tasks were solved in the dissertation:

1. Investigate the background and significance of distorted QR code correction algorithm.
2. Analyze the application status of QR code technology.
3. Research existing methods.
4. Develop a correction method for distorted QR codes.
5. Implementation of QR code image preprocessing module.
6. Implementation of Hamming Code correction distortion QR code Module.
7. Conduct experiments.
8. Result analysis.

Personal contribution of the author

Setting and conducting experiments to study characteristics, assessing the efficiency of the developed algorithms, processing and analyzing the obtained results, formulation of conclusion.

Testing and implementation of results

The main provisions and results of the dissertation work were reported and discussed at Belarusian State University of Informatics and Radioelectronics.

The results of the thesis were used in educational process in ITAS Educational institution Belarusian State University of Informatics and Radioelectronics in the course Systems of Analytical Programming (lecturer dr. German O.V.)

Author’s publications

According to the results of the research presented in the dissertation, 2_author’s works was published, including: 2 articles in scientific journals recommended by the the 59 th BSUIR Technology and ITS 2022 Conference, with a total amount of 4 author’s pages.

Structure and size of the work

The dissertation work consists of introduction, general description of the work, three chapters with conclusions for each chapter, conclusion, bibliography, five appendixes.

The total amount of the thesis is 79 pages, of which 52 pages of text, 22 figures on 15 pages, 5 tables on 4 pages, a list of used bibliographic sources (34 titles on 3 pages), a list of the author's publications on the subject of the thesis (2 titles on 1 pages), 5 appendixes on 5 pages, graphic material on 7 pages.

SUMMARY OF THE WORK

The introduction provides an overview of the challenges faced by distorted QR codes and highlights the significance of developing a correction algorithm. It establishes the connection between the research work and the priority areas of scientific research in the field of information technologies and control. The aim and tasks of the research are outlined, along with the applicant's personal contribution to the advancement of knowledge and scientific degree. The dissertation results are also discussed in terms of their validation and approval.

The general description of the work demonstrates the alignment of the research with priority areas of scientific research. The aim of the research is to develop a distorted QR code correction algorithm, which falls within the broader scope of digital information and communication technologies, specifically focusing on artificial intelligence, big data, and cloud technologies. The research tasks include investigating the background and significance of the algorithm, analyzing the status of QR code technology, researching existing methods, developing a correction method, implementing necessary modules, conducting experiments, and analyzing the results.

The personal contribution of the applicant for a scientific degree includes setting up and conducting experiments, assessing the efficiency of the developed algorithms, processing and analyzing the obtained results, and formulating conclusions. The research findings were presented and discussed at the Belarusian State University of Informatics and Radio electronics, and they have been utilized in the educational process at the ITAS Educational institution within the same university.

The dissertation results have also been disseminated through publications, including articles in scientific journals recommended by the 59th BSUIR Technology and ITS 2022 Conference. These publications contribute to the wider scientific community and showcase the author's work in the field.

In the first chapter, the research analyzes existing methods and techniques related to correct QR codes. It provides a comprehensive review and evaluation of the current approaches, offering a theoretical foundation for the development of the proposed algorithm.

The second chapter presents the distorted QR code correction algorithm. It describes the two main modules of the algorithm: the QR code image preprocessing module and the Hamming code correction module. The preprocessing module focuses on noise reduction, enhancement, and deformation correction of the QR

code image. As the Figure 1.1 show the whole modules is employed to rectify errors and distortions in the QR code.

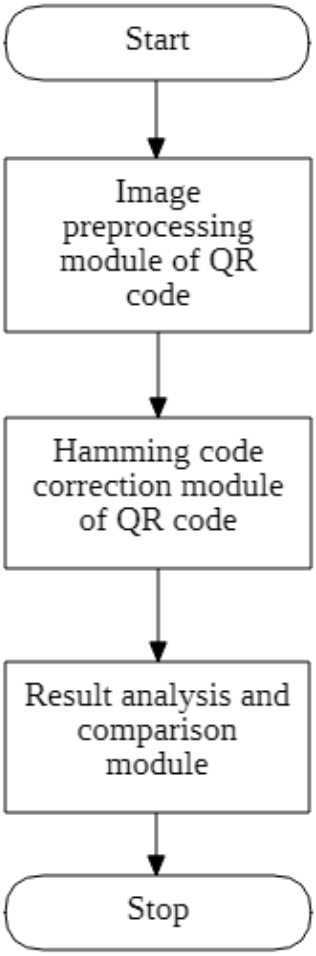

Figure 1.1 - Whole modules to correct distorted QR-code

The third chapter covers the software implementation of the algorithm. It details the programming tools used, provides a code description, and offers a user guide for applying the algorithm in practical scenarios. The chapter also discusses potential avenues for future development and improvement of the algorithm.

Overall, the work successfully addresses the challenges associated with distorted QR codes and proposes a novel correction algorithm. The research demonstrates the author's contribution to the field of information technologies and control through the development and implementation of the algorithm. The algorithm's effectiveness and performance are validated through experimental analysis. The findings of this work contribute to the advancement of QR code recognition technology and its applications in various fields.

CONCLUSION

The thesis has introduced a novel and efficient method for correct distorted QR codes. By leveraging the power of Hamming codes, the proposed algorithm effectively detects and corrects errors introduced during encoding, printing, and other sources of distortion. This innovative approach ensures fast and reliable correction and recognition of QR code, improving readability and usability.

Additionally, the thesis has developed a robust identification mechanism for distorted QR code. Through the utilization of Hamming codes, the algorithm accurately identifies QR codes even in the presence of significant distortion. This identification capability contributes to the overall reliability and effectiveness of QR code-based systems.

A programming application has been created as part of this research, implementing the developed restoration and identification methods. The application provides a practical and user-friendly tool for restoring and identifying distorted QR codes. It offers seamless integration with existing QR code scanning systems and can be easily adopted in various domains.

The research has conducted a series of experiments to evaluate the performance of the proposed methods. These experiments involved a diverse range of distorted QR codes, simulating real-world scenarios. The results obtained from the experiments demonstrate the effectiveness and efficiency of the restoration and identification methods, validating their practical applicability.

Importantly, the developed method for restoring and identifying distorted QR codes holds potential for broader application in image processing. The underlying principles and techniques can be extended and adapted to address challenges in various image processing tasks, such as image restoration, object recognition, and computer vision applications.

And the number of failures (2/60) also indicates that Hamming code may not be able to effectively correct distortions in some cases. This may be due to the degree of distortion beyond the range of Hamming code's error correction capabilities, or there are other complex factors that cause the error correction to fail. Hamming code can successfully correct distorted QR codes in most cases, but there may be limitations in dealing with some extreme cases.

In general, the research in this thesis is of great significance to the correction algorithm and application of distorted QR codes, provides theoretical and technical support for the application of QR codes in various fields, and helps to promote the further development and application of QR code technology.

LIST OF AUTHOR'S PUBLICATIONS

1. Feiyu,X. Distorted QR code correction algorithm/ Xiao Feiyu,O.V. German // Information Technologies and Systems 2022 (ITS 2022): Proc. of the International Conference, 23 November 2022 / BSUIR, Minsk – 2022. –P. 141–142.

2. Feiyu,X. Positioning and correction of distorted QR-code / Xiao Feiyu // 59th conference of postgraduate students, undergraduates and students of the educational institution "Belarusian State University of Informatics and Radioelectronics", 17-21April 2023 / BSUIR, Minsk – 2023. – P. 57–58.