https://doi.org/10.31891/csit-2023-3-11
UDC 004.9: 004.05

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AUTOMATED TESTING OF WEB PROJECT FUNCTIONALITY WITH USING OF ERROR PROPAGATION ANALYSIS

Automated testing is indispensable in the area of software engineering, particularly for web project functionality, as the complexity of software systems continues to surge. This paper delves into the pivotal role of automated testing and how the integration of error propagation analysis, grounded in chaos theory, can elevate its efficacy. The objective is to elucidate the significance of this methodology and its application in bolstering the reliability and performance of web projects. Automated testing automates the execution of predefined test cases, offering efficiency gains, reduced human error, and swift defect detection in software development. Various testing approaches, including unit testing, integration testing, and regression testing, cater to distinct facets of software functionality, ensuring seamless operation of all components. Web project functionality is integral to the user experience, encompassing navigation menus, forms, and search features. Testing this functionality is imperative to unearth inconsistencies or errors that could compromise user satisfaction and task completion.

This paper proposes a methodology for automated testing coupled with error propagation analysis, which involves scrutinizing how errors evolve through a system over time. Chaos theory, a branch of mathematics examining complex systems' behavior, is employed to understand how minor variations in initial conditions can precipitate substantial system behavior shifts.

Traditional error propagation analysis hinges on linear, deterministic models, but real-world systems often exhibit non-linear, chaotic characteristics, rendering such models inadequate. Chaos theory's non-linear dynamics model the intricate interactions between input variables and their effects on outputs, capturing the sensitivity of chaotic systems to initial conditions. This approach appreciates system complexity and intricate feedback loops, enhancing error analysis's robustness and accuracy. However, the application of chaos theory introduces complexity and computational demands, necessitating a balance between model intricacy and practicality. The proposed methodology unveil valuable insights into error propagation within web projects' functionality, pinpointing vulnerable components and areas ripe for improvement. The methodology's advantages include the ability to identify potential issues and vulnerabilities, ultimately enhancing web project reliability.

Keywords: web project functionality testing, automated testing, error propagation analysis, chaos theory, instability.

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АВТОМАТИЗОВАНЕ ТЕСТУВАННЯ ФУНКЦІОНАЛЬНОСТІ ВЕБ-ПРОЄКТУ З ВИКОРИСТАННЯМ АНАЛІЗУ ПОШИРЕННЯ ПОМИЛОК

Автоматизоване тестування є незамінним у сфері розробки програмного забезпечення, особливо для функціональності веб-проєктів, оскільки складність програмних систем продовжує зростати. У цій статті розглядається ключова роль автоматизованого тестування та те, як інтеграція аналізу поширення помилок, заснованого на теорії хаосу, може підвищити його ефективність. Мета полягає в тому, щоб з'ясувати значення цієї методології та її застосування для підвищення надійності та продуктивності веб-проєктів. Автоматизоване тестування автоматизує виконання попередньо визначених тестів, пропонуючи підвищення ефективності, зменшення людських помилок і швидке виявлення дефектів у розробці програмного забезпечення. Різні підходи до тестування, включаючи модульне тестування, інтеграційне тестування та регресійне тестування, задовольняють різні аспекти функціональності програмного забезпечення, забезпечуючи безперебійну роботу всіх компонентів. Функціональні можливості веб-проєкту є невід'ємною частиною взаємодії з користувачем, охоплюючи навігаційні меню, форми та функції пошуку. Тестування цієї функції є обов'язковим, щоб виявити невідповідності або помилки, які можуть поставити під загрозу задоволення користувачів і виконання завдань.

У статті пропонується методологія автоматизованого тестування в поєднанні з аналізом розповсюдження помилок, що передбачає ретельний аналіз того, як помилки розвиваються в системі з часом. Теорія хаосу - це розділ математики, що вивчає поведінку складних систем, використовується для розуміння того, як незначні варіації початкових умов можуть спричинити значні зміни поведінки системи.

Традиційний аналіз розповсюдження помилок базується на лінійних, детермінованих моделях, але реальні системи часто демонструють нелінійні, хаотичні характеристики, що робить такі моделі неадекватними. Нелінійна динаміка теорії хаосу моделює складну взаємодію між вхідними змінними та їхній вплив на результати, фіксуючи чутливість хаотичних систем до початкових умов. Цей підхід оцінює складність системи та заплутані цикли зворотного зв'язку, підвищуючи надійність і точність аналізу помилок. Однак застосування теорії хаосу створює складність і потребує обчислень, що вимагає балансу між складністю моделі та практичністю. Запропонована методологія розкриває цінну інформацію про розповсюдження помилок у функціональності веб-проєктів, визначаючи вразливі компоненти та області, які потребують вдосконалення. Переваги методології включають можливість виявлення потенційних проблем і вразливостей, що в кінцевому підсумку підвищує надійність веб-проєкту.

Ключові слова: тестування функціональності веб-проєкту, автоматизоване тестування, аналіз поширення помилок, теорія хаосу, нестабільність.

Introduction

Automated testing of web project functionality [1] with error propagation analysis is a crucial aspect of software engineering [2,3]. As technology continues to advance rapidly, software systems become increasingly complex, and ensuring their functionality becomes more challenging. Testing plays a vital role in identifying and rectifying any issues or vulnerabilities that may arise during the development process [2,4,5]. In this paper, we will explore the significance of automated testing and how error propagation analysis incorporating chaos theory can be applied to enhance this method [6].

Automated testing refers to the use of tools and frameworks to execute predefined test cases automatically. It offers several benefits in software development, including increased efficiency, reduced human error, and faster detection of defects or bugs. There are various approaches to automated testing, such as unit testing, integration testing, and regression testing [1,7–9]. Each approach focuses on different aspects of software functionality and helps ensure that all components work together seamlessly.

Web project functionality refers to the ability of a website or web application to perform its intended tasks accurately and efficiently [9]. The user experience heavily relies on the proper functioning of web projects' features such as navigation menus, forms, search functionalities, etc. Testing web project functionality is essential for identifying any inconsistencies or errors that may hinder user satisfaction or impede successful completion of tasks [2,3].

The primary objective of web project functionality test is the evaluating whether the features and functions of a web application align with the project's requirements [1]. This testing phase is instrumental in identifying defects, anomalies, and inconsistencies within the web project, thereby ensuring that it meets user expectations and business goals.

The functionality of the web application is rigorously evaluated, including user interactions, data processing, and system operations. Each feature's behavior is meticulously assessed against predefined test cases. The web project can be tested across various browsers, devices, and operating systems to guarantee seamless functionality for a diverse user base. Assessing the responsiveness and scalability of the web project under varying loads and conditions is crucial to ensure an optimal user experience. Detecting vulnerabilities and ensuring the protection of sensitive user data is a pivotal component of functionality testing to safeguard against potential threats. Functionality testing is indispensable in ensuring the basic usability of a web project [10,11]. However, it may not provide a comprehensive view of the application's resilience to unforeseen issues and potential error propagation.

Error propagation analysis extends the evaluation of web projects beyond functionality testing. There are sophisticated techniques employed to understand how errors or issues in one part of the web project can ripple through other interconnected components. Often used in conjunction with functionality testing, error propagation analysis offers a deeper understanding of the application's reliability. The analysis begins by mapping out the intricate dependencies between different modules, components, and functions of the web project, shedding light on how data and errors can flow between these interconnected elements [2,3].

Various types of errors or faults are simulated at different points within the web application to gauge how they propagate through the system. These errors may include input validation issues, database connection failures, or network errors. Once errors are introduced, analysts assess their impact on the web project's functionality, performance, and security. They ascertain how errors influence the user experience and whether they lead to data corruption or system instability.

Error propagation analysis aids developers and testers in understanding the web project's ability to handle errors gracefully. It facilitates the identification of potential error recovery mechanisms and the reinforcement of error-handling processes. By pinpointing critical points of error propagation, web project teams can prioritize the resolution of high-risk areas, reducing the likelihood of system failures and data breaches [3].

Thus, web project functionality testing is an indispensable step in ensuring the usability of web applications. However, it may fall short in identifying vulnerabilities stemming from error propagation. Error propagation analysis serves as a vital complement to functionality testing, providing a holistic view of a web project's resilience to errors and failures. By combining these two approaches, web developers and quality assurance teams can create robust and dependable web applications that not only meet user expectations but also withstand the challenges of the digital landscape. This, in turn, enhances the overall user experience and security of the web project, making it a critical aspect of modern web development.

Therefore, automated testing of web project functionality is *an actual task* today.

The purpose of this study is to develop methodology for automated testing with error propagation analysis.

Methodology for Automated Testing with Error Propagation Analysis

Error propagation analysis involves studying how errors propagate through a system over time. In software engineering, it helps identify potential issues or vulnerabilities by analyzing how errors affect different components within a system or application stack[12]. By understanding how errors propagate throughout a system's architecture, developers gain valuable insights into areas that require attention during the testing phase [6,11].

Chaos theory is a mathematical concept that explores the behavior of complex systems that are highly sensitive to initial conditions [13,14]. It has found application in various fields, including physics, biology, and economics. When applied to web project functionality testing, chaos theory enables us to understand how slight variations in initial conditions can lead to significant differences in system behavior [15–17].

Error propagation analysis is a fundamental concept in various scientific disciplines, including physics, engineering, and computer science. It involves assessing how uncertainties in input variables propagate through a system to affect the uncertainty in the output or result. While traditionally approached through deterministic and linear models, the application of chaos theory to error propagation analysis offers a fresh perspective that acknowledges the inherent complexity and non-linearity of real-world systems. In this paper, we will explore the integration of chaos theory principles into error propagation analysis, highlighting its benefits and implications. Traditionally, error propagation analysis relies on linear and deterministic models, such as the Gaussian error propagation formula, which assumes that errors in input variables are normally distributed and that the relationships between variables are linear. This approach has been successful in many scenarios, especially when dealing with simple systems and small uncertainties. However, real-world systems are often non-linear, chaotic, and subject to complex interactions, making deterministic and linear models inadequate for capturing their behavior accurately [6,18].

Chaos theory, initially developed to understand the behavior of dynamic systems that appear random but are governed by underlying deterministic processes, offers a powerful framework for error propagation analysis [19]. Chaos theory deals with non-linear dynamics, where small changes in initial conditions can lead to significant variations in outcomes, a phenomenon known as the butterfly effect. By embracing chaos theory, error propagation analysis can better account for the complexity and unpredictability inherent in many systems.

Chaos theory enables the modeling of non-linear interactions between input variables and their effects on the output. This is particularly valuable when dealing with systems where small errors in initial conditions or input variables can lead to dramatic and unexpected consequences [10,20]. The theory acknowledges the sensitivity of chaotic systems to initial conditions, highlighting that seemingly insignificant changes in inputs can propagate into substantial differences in outcomes. Error propagation analysis benefits from this perspective by accounting for the sensitivity of real-world systems. The methods of nonlinear dynamics emphasize the complexity of dynamic systems and the presence of complex feedback loops. When applied to error propagation analysis, this recognition allows for more accurate modeling of the interactions between variables, which may not adhere to linear assumptions.

By embracing chaos theory, error propagation analysis can provide a more robust understanding of the uncertainties associated with a system's outputs. This can be particularly crucial in critical applications such as aerospace, finance, and healthcare, where small errors can have significant consequences.

While integrating chaos theory into error propagation analysis offers significant benefits, it also presents challenges. Chaos theory often involves the use of complex mathematical models, which may require sophisticated computational tools and resources. Moreover, the implementation of such models may be more time-consuming and computationally intensive than traditional linear approaches. Therefore, it is essential to strike a balance between model complexity and practicality when applying chaos theory to error propagation analysis.

Thus, the integration of chaos theory into error propagation analysis represents a promising avenue for improving our understanding of complex, non-linear systems. By embracing the principles of chaos theory, error propagation analysis can better account for the inherent uncertainty, non-linearity, and sensitivity to initial conditions present in real-world systems. While challenges exist in implementing these models, the potential benefits, including more accurate predictions and enhanced robustness, make chaos theory a valuable tool for error propagation analysis in various scientific and engineering disciplines. As our understanding of chaos theory and its applications continues to evolve, it promises to provide deeper insights into the behavior of complex computer systems and how they propagate errors.

Our proposed methodology for automated testing using error propagation analysis builds upon the principles of chaos theory. By analyzing the sensitivity of web project functionality to initial conditions, we can identify potential points of failure or instability, as described in [21]. The steps involved in implementing this methodology include:

Experiments conducted using our methodology have yielded insightful findings regarding error propagation within web projects' functionality [22]. We observed certain trends where specific components exhibited higher vulnerability to errors than others, highlighting potential areas for improvement during development.

The proposed method for automated testing with error propagation analysis offers several advantages but also presents limitations worth considering. One limitation is determining an optimal balance between complexity and feasibility of the test scenarios. Additionally, the method heavily relies on accurate modeling of initial conditions and system behavior.

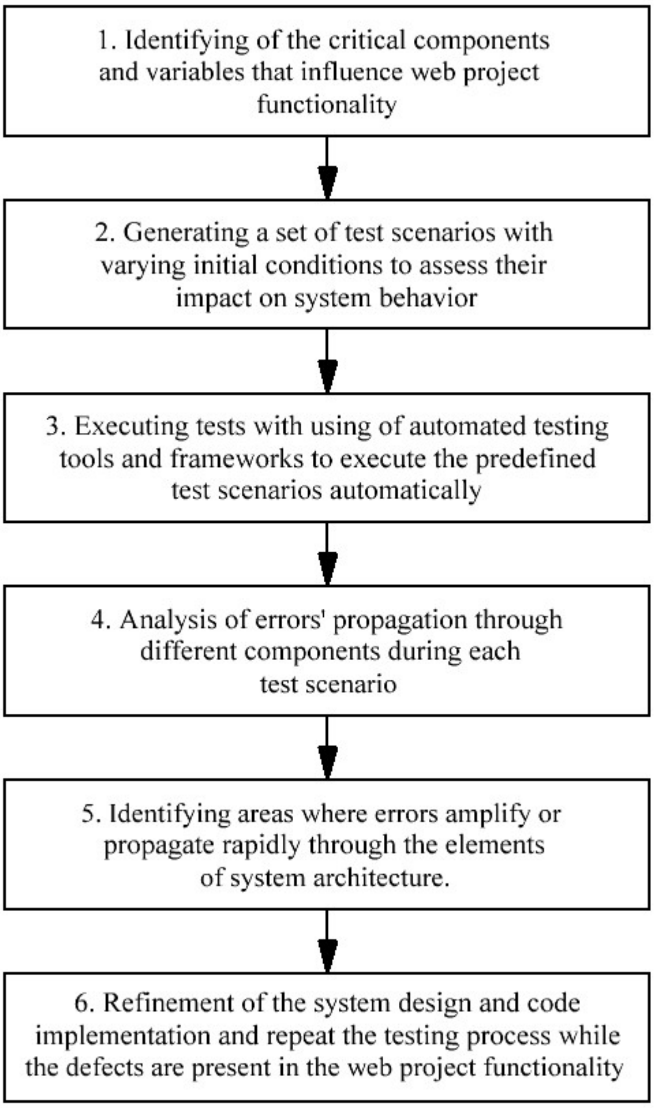

Fig. 1. The proposed methodology for automated testing using error propagation analysis

Conclusions

Automated testing with error propagation analysis is a valuable approach to ensure web project functionality. By incorporating chaos theory principles, this methodology allows developers to identify potential issues or vulnerabilities within a system's architecture and take appropriate measures for improvement [12]. The significance of automated testing cannot be overstated in improving user experience and overall software quality. Moving forward, further research can focus on refining the proposed methodology, addressing its limitations, and exploring additional applications in different domains. As software engineering continues to evolve rapidly, automated testing will remain an essential practice in ensuring the reliability and functionality of web projects.

In conclusion, automated testing combined with error propagation analysis is a powerful tool in software engineering that enables developers to identify weaknesses and enhance the functionality of web projects effectively. By leveraging chaos theory principles and considering initial conditions sensitivity, this methodology provides valuable insights into how errors propagate through complex systems. With further research and refinement, it holds great potential for improving software development practices across various domains.

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