IMPROVING SOFTWARE DEVELOPMENT QUALITY ASSURANCE PROCESS WITH COMPUTER VISION TECHNIQUES

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Abstract. *In the evolving landscape of software engineering, quality assurance* (*QA*) *has become increasingly challenging due to the complexity of graphical user interfaces* (*GUIs*)*, the rapid iteration of user-centric applications, and the limitations of manual and code-based testing frameworks. This paper investigates how computer vision* (*CV*) *techniques can improve QA processes by introducing visual-level automation and perception-based testing strategies. Drawing from key studies, this work highlights the achievements and future potential of CV-powered approaches in GUI testing, automated validation, and intelligent interaction with software systems.*

Keywords**:** *software testing, computer vision, GUI automation.*

Software quality assurance ensures that products meet functional and design requirements while maintaining usability, performance, and maintainability. Traditional QA relies heavily on manual testing and code-based test scripts, which are often brittle, time-consuming, and fail to scale with frequent GUI updates. Such metric-driven and structural approaches, as demonstrated by Prykhodko et al. (2024) in their statistical modeling of object-oriented design complexity, remain valid and effective for assessing software quality [1]; however, computer vision-based methods can complement these by addressing visual and interaction-level aspects of testing. As software applications increasingly prioritize graphical interfaces and user experience, there is a growing need to automate visual aspects of testing.

Computer vision offers a novel solution: enabling machines to perceive and interpret interfaces similarly to human testers. Instead of relying solely on code identifiers or DOM structures, CV-based methods operate on screenshots, layouts, and rendered UI states. This paper explores how computer vision augments the QA process, synthesizing key developments and suggesting future directions.

Table 2

Challenges of Computer Vision-Based QA

Factor	Characteristic
Dynamic Content Handling	GUIs often contain dynamic elements such as animations, pop-ups, or ads. CV systems may struggle to differentiate between intentional design changes and transient UI behaviors
Lack of Semantic Understanding	Unlike humans, CV models may fail to grasp contextual meanings (e.g., distinguishing a "Submit" button from a similar-looking "Cancel" button) unless paired with NLP or metadata
Scalability to Diverse Layouts	CV models trained on specific design styles may not generalize well across diverse UI themes or platforms. Training and maintaining adaptable models are resource-intensive
Testing Environment Variability	Slight differences in rendering due to device resolution, browser engines, or operating systems can lead to false positives in visual comparisons
Tooling and Integration Complexity	Integrating CV tools into CI/CD pipelines requires robust infrastructure, standardization of visual artifacts, and tight coordination between developers, testers, and designers

Recognizing and addressing these limitations is critical for realizing the full potential of CV-driven QA frameworks.

The integration of computer vision into QA is still evolving. Future developments may include:

– Vision-Language Models that directly interpret human-written test cases into visual validations;

– Self-Healing Test Suites where CV identifies and adapts to UI changes dynamically;

– Model Generalization enabling CV systems to handle diverse design styles and dynamic content with high accuracy;

– Integration into CI/CD Pipelines for real-time visual testing as part of automated workflows.

The synergy of CV with AI, natural language processing, and human-centered design opens up new paradigms for intelligent, adaptive software testing.

In conclusion, computer vision provides a transformative approach to software quality assurance by enabling systems to perceive, understand, and validate visual interfaces like human testers. Through the incorporation of CV-based techniques, organizations can reduce manual effort, improve defect detection, and ensure consistent user experience across platforms. As CV technologies continue to mature, their impact on software development

workflows is poised to grow significantly, aligning with the broader shift toward intelligent automation. Despite challenges in generalizing across diverse visual domains and dynamic content, the trajectory of CV-enhanced QA suggests a paradigm shift toward more resilient, scalable, and intelligent software testing methodologies.

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POTENTIAL IN STRENGTHENING UKRAINE'S ENERGY SECURITY THROUGH DIVERSIFICATION OF ENERGY SUPPLY SOURCES

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Abstract. *The importance of a reliable energy security system is substantiated. The definition of diversification of energy sources and the advantages of its application are given. Specific examples of the implementation*