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A deep learning-based worker assistance system for error prevention: Case study in a real-world manual assembly

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ABSTRACT

Modern assembly systems adapt to the requirements of customised and short-lived products. As assembly tasks become increasingly complex and change rapidly, the cognitive load on employees increases. This leads to the use of assistance systems for manual assembly to detect and avoid human errors and thus ensure consistent product quality. Most of these systems promise to improve the production environment but have hardly been studied quantitatively so far. Recent advances in deep learning-based computer vision have also not yet been fully exploited. This study aims to provide architectural, and implementational details of a state-of-the-art assembly assistance system based on an object detection model. The proposed architecture is intended to be representative of modern assistance systems. The error prevention potential is determined in a case study in which test subjects manually assemble a complex explosion-proof tubular lamp. The results show 51 % fewer assembly errors compared to a control group without assistance. Three of the four considered types of error classes have been reduced by at least 42 %. In particular, errors by omission are most likely to be prevented by the system. The reduction in the error rate is observed over the entire period of 30 consecutive product assemblies, comparing assisted and unassisted assembly. Furthermore, the recorded assembly data are found to be valuable regarding traceability and production improvement processes.

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Izvirni znanstveni članek

Sistem za pomoč delavcem za preprečevanje napak, ki temelji na globokem učenju: Študija primera ročne montaže v realnem industrijskem okolju

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POVZETEK

Sodobni montažni sistemi se prilagajajo zahtevam prilagojenih izdelkov s kratkimi življenjskimi dobami. Ker postajajo montažne naloge vse bolj zapletene in se hitro spreminjajo, se povečuje kognitivna obremenitev zaposlenih. To vodi do uporabe podpornih sistemov za odkrivanje in izogibanje človeškim napakam pri ročni montaži ter pripomore k zagotavljanju dosledne kakovosti izdelkov. Večina teh sistemov obljublja izboljšanje produkcijskega okolja, vendar to doslej še ni bilo kvantitativno raziskano. Nedavni napredek v strojnem vidu, ki temelji na globokem učenju, prav tako še ni bil v celoti izkoriščen. Namen te študije je predstaviti arhitekturne in izvedbene podrobnosti najsodobnejšega sistema za pomoč pri montaži, ki temelji na modelu zaznavanja objektov. Predlagana arhitektura naj bi predstavljala merilo za sodobne podporne sisteme. Možnost preprečevanja napak je ugotovljena v študiji primera, v kateri testni subjekti ročno sestavijo zahtevno, proti eksploziji varno cevno svetilko. Rezultati kažejo 51 % manj napak pri montaži v primerjavi s kontrolno skupino brez pomoči. Tri od štirih obravnavanih vrst napak so se zmanjšale za najmanj 42 %. Sistem bo najverjetneje preprečil zlasti napake zaradi izpustitve sestavnih delov. Zmanjšanje pogostosti napak je opaziti v celotnem obdobju 30 zaporednih sestavljanj izdelka, če primerjamo montažo s pomočjo sistema in brez njega. Poleg tega se je izkazalo, da so zabeleženi podatki o montaži dragoceni tudi zaradi sledljivosti in izboljšanja proizvodnje.

PODATKI O ČLANKU

Ključne besede:
Globoko učenje;
Strojno učenje;
Industrija 4.0;
Pametna proizvodnja;
Ročna montaža;
Podporni sistem;
Preprečevanje napak;
Zaznavanje predmetov

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