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Opinion Article

Human-Robot Collaboration in Product Remanufacturing

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DESCRIPTION

Remanufacturing of End-of-Life (EoL) products is a critical step in effectively recovering high value components and materials from products. Statistics show that unscrewing is one of the main tasks in remanufacturing. Human-Robot Collaboration (HRC) is a rational strategy to harness the power of humans and robots to unscrew bolts under various rust conditions. Nevertheless, MRK's capacity for cooperation, safety and demolition efficiency needs to be improved. To address this issue, this article develops his innovative HRC approach for screw removal in EoL products enabled by the Stackelberg model. This approach can address the dynamic and uncertain characteristics of human operators to achieve human-centric HRC decomposition. This approach demonstrates the advantages of the Stackelberge model considering decomposition efficiency and human-robot safety. The innovative Particle Swarm Optimization (PSO) Pareto Algorithm (PSO-Pareto) was developed to achieve the best performance in terms of safety and demolition efficiency. The effectiveness and generality of this approach were validated through experiments and case studies, and various design benchmarks proved the approach's superiority.

Disassembly is a key process in remanufacturing to recover high-value components or materials from end-of-life (EoL) products. Currently, almost all dismantling of used products is done manually. However, this is a labor intensive and costly process. On the other hand, EoL products usually contain toxic substances and contaminants that are harmful to human operators. Therefore, manual disassembly has become less common in modern industries and societies. A future trend is to develop robotics and intelligent technologies that facilitate automated or semi-automated demolition processes.

Screws are fastening parts that are indispensable to products. According to statistics, 39.9% of demolition work involves loosening screws. Therefore, to achieve automated disassembly, it is necessary to effectively remove screws from end-of-life products. Study is currently underway to use robotics to dismantle obsolete screws. Most of the developed approaches were used to dismantle bolts in good condition (normal bolts). Instead, screw rusting, which is inevitable with long-life EoL products, is a challenge for robotic handling. Human operators can cope with non-standard conditions such as rusty bolts, but there are limits to high-efficiency operation. This is driving the adoption of collaborative robots (cobots) in industry to enable robots to work side by side with humans. H. Human Robot Collaboration (HRC) for demanding disassembly needs. A compelling research topic now is his development of effective HRC strategies to leverage the strengths of robots and humans to achieve disassembly flexibility and efficiency.

CONCLUSION

Game theory was originally developed to solve economic decision-making problems. It has since been successfully used in various applications in finance, biology, and computer science. In game theory, the Stackelberg model is an effective joint strategy. The model determines leaders and followers during collaboration. Leaders choose their first actions according to their goals. Followers make their own decisions based on the leader's actions. Both the leader and follower then iteratively adjust their behavior in pursuit of their best interests until they reach a Nash equilibrium (Nash equilibrium means that if a leader or follower changes their current means no results). The Stackelberg model is well suited for designing his HRC-based disassembly of EoL products. The basic idea is that in HRC-based dismantling processes, human operators should play a leading role in the action, and robots should play a trailing role to ensure human safety. After the model reaches Nash equilibrium, humans and robots achieve optimal decomposition strategies and functions.

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