The Convergence of Control and Cognition: A Bibliometric Overview of UKF in AI-Infused Robotics

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ABSTRACT

This paper gives a bibliometric summary of Unscented Kalman Filter (UKF) in AI-infused robotics, highlighting its role in unifying control and cognition. Using a systematic approach that includes literature collection from IEEE Xplore, Web of Science and Google Scholar, rigorous screening and selection, and VOSviewer for a comprehensive bibliometric analysis. This analysis reports major trends, primary contributors and central themes, highlighting UKF's pivotal role in improving robotics cognitive and control capacities. The study emphasizes the universally used UKF in many fields of robotics, i.e. in navigation and mapping, sensor fusion, and state estimation, as one of its principal developers, which illustrates its vital role in promoting robotic autonomy and intelligence. The integration of findings from the bibliometric analysis thus not only presents the current state of research but also identifies possible future research directions, highlighting the increasing unification of control theories and cognitive processes in robotics. This research adds to the body of knowledge by delivering a comprehensive map of the UKF application. In this light, the UKF will be able to penetrate AI-infused robotics, the future of robotic developments will rely on the deep fusion of control and cognition facilitated by UKF and alike.

Keywords: Unscented Kalman Filter, UKF, Robotics, VOSviewer, Bibliometric

INTRODUCTION

Artificial intelligence (AI) [1-8] and robots [9-20] have given birth to a new wave of technological break throughs whereby the fusion of control systems with cognitive capabilities is not merely a dream but a reality that is not only being improved but also exploited with passion. The convergence is underlined by the Unscented Kalman Filter (UKF) [21-33], a sophisticated algorithm that has done a lot in advancing the abilities of AI-based robotics [34-48]. The ability of UKF to provide accurate state estimation in non-linear systems is not only precise but also invaluable to the development of robotic systems with higher levels of autonomy and intelligence [49-55]. This paper aims at giving a bibliometric analysis of the application of UKF in AI-infused robotics, with emphasis on how this technology forms the basis for the blending of control and cognition.

By providing an extensive review of literature and trends, the study seeks to illuminate the central function played by UKF in fostering the cognitive and control capabilities in robotic systems. This research dissects the complex web of UKFs applications by critically collecting and integrating relevant academic articles, conference papers, and journals, identifying key contributors, emergent themes and future research directions. The importance of the reincarnation resides not just in the illumination of the current landscape but in drawing the way to the unification of control theories and cognitive processes thus improving the functionality, efficiency, and adaptivity of robots in multiple applications.

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METHODOLOGY

Figure 1 indicates that this research employs a detailed bibliometric analysis [56-61] to explore the unification of control and cognition in AI-infused robotics, namely, the implementation of the Unscented Kalman Filter (UKF). Our methodology is systematically divided into four main stages: Literature Collection, Screening, Selection, Bibliometric Analysis, and Synthesis. Every stage is aimed at providing the detailed study of UKF in the robotics domain and synthesis of knowledge in this sphere, which thus reveals the role of UKF in integration of control systems and cognitive processes. The initial phase of our research involved an exhaustive literature collection process targeting three major digital databases: IEEE Xplore, Web of Science and Google Scholar. These sites were selected due to their rich collection of scholarly articles, conference papers, and journals across multiple disciplines, which include robotics, artificial intelligence, control systems, and cognitive sciences. The search criteria was smartly formulated such that it included articles that apply UKF in the domain of AI-inspired robotics. Keywords and search queries were systematically formulated to capture the whole spectrum of research work on UKF, hence making sure that a comprehensive coverage of relevant literature was achieved. After the literature collection was completed, a thorough screening and selection approach were used. This was a vital stage in the process of eliminating articles that did not directly relate to our research area of interest – the fusion of control and cognitive functions in robotics using UKF. Precedence was given to scholarly works that showed a high impact, relevance, and contribution to the field. Other considerations made included the citation count, journal impact factor, and relevance of findings in demonstrating the convergence of control and cognition. Thus, such rigorous procedure guaranteed that only the papers that made considerable impact towards the understanding of UKF applications in robotics were chosen for further analysis.

Using a tamed set of literature, we performed a bibliometric analysis employing several bibliometric tools. This evaluation helped us to quantitatively analyze trends, major contributors, geographical distributions, and core themes in the implementation of UKF in AI and robotics. Network analysis was carried out in order to visualize the correlation between the major research areas, authors and institutions, giving a picture of collaboration networks and intellectual landscapes in the field. Frequency analysis of keywords and topics helped us figure out emerging themes and the changes in research focus over time.

The last step was to consolidate the findings from the bibliometric analysis which outlined key research paths and areas for future research in the utilization of UKF in robotics. This synthesis was aimed at summary of the findings to show the role of UKF applications in promoting the cognitive and control capabilities of robotic systems. After integrating the quantitative details obtained from the bibliometric analysis with a qualitative review of the selected articles, the gaps in the current research landscape were identified, and areas for future study were suggested. This comprehensive view did not only represent the current state of UKF applications in robotics but also exposed the possibility of further control and cognitive functions integration for the future research in this sense.

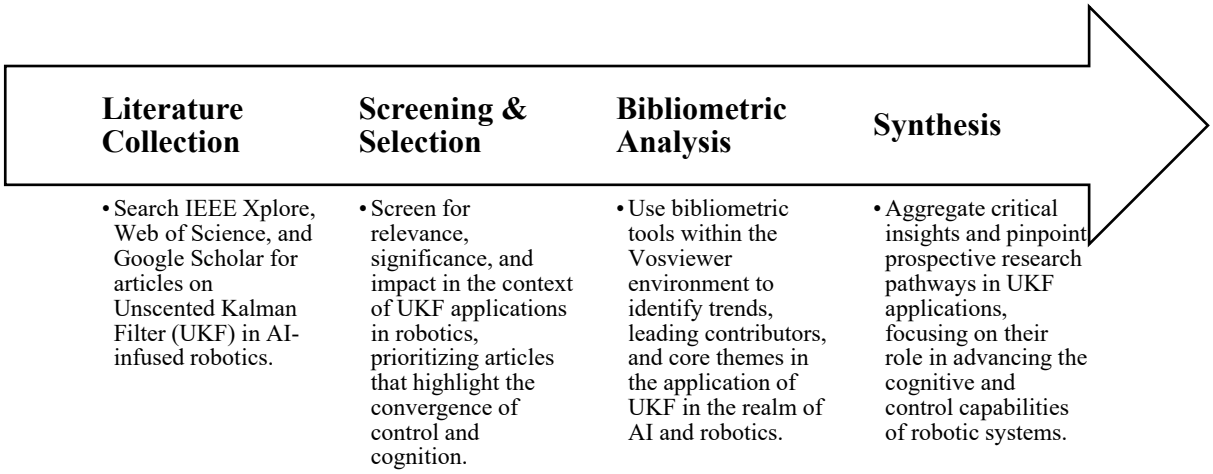

Figure 1 Research methodology

RESULTS AND DISCUSSION

Based on the VOSviewer bibliometric analysis of Figure 2, we delve into insights regarding the occurrence and clustering of the key terms associated with the application of UKF in AI-infused robotics. The data provides substantial information about the research field, which demonstrates the convergence of the multiple concepts and technologies in robotics, control theory, and computer vision.

Dominant here is the “extended kalman filters,” which largely overweighs other terms with its frequency of appearance. This highlights the key place of Kalman filter methods in the development of AI-based robotics. The notoriety of “kalman filters” and “extended kalman filters” reveals the indispensability of these algorithms in achieving accurate state estimation and sensor fusion, which are crucial for the advancement of intelligent robotic systems [62-78].

The notion "robotics" becomes an important node that characterizes the manifold applications of UKF in robotics. The high appearances of “mobile robots,” “navigation,” and “robot applications” also exemplify the broad usage of UKF in different robotic operations. This points to a development toward improving autonomous functions in which UKF is central to making robots able to properly perceive and traverse their surroundings.

The analysis indicates a substantial convergence of technologies and disciplines. “Computer vision” and “cameras” are closely related, pointing to the feeding of visual data into robotic systems for improved perception and decision-making. In the same way, “global positioning system” and “indoor positioning systems” and “localization” coupling reflects the significance of precise positioning in the operational efficiency of robotics, especially in navigation and mapping [79-82]. Found clusters around “control theory,” “estimation,” and “intelligent robots” suggest a change of attention towards the cognitive aspect of robotics [75, 77, 83-104]. All of these terms, including sensor fusion and state estimation, lead to a development in the direction of robotic systems’ capability to process and combine information from various sources for smarter decision-making and control.

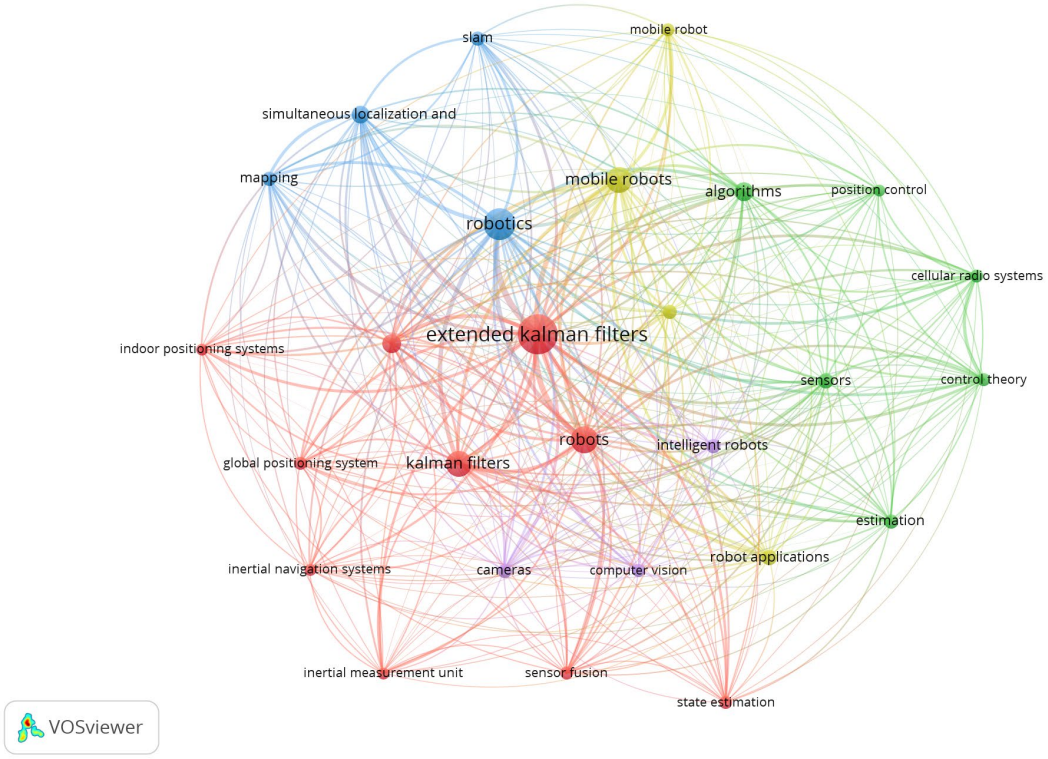

Figure 2 Thematic Clusters of Top Keywords

CONCLUSION

The bibliometric overview in this paper emanates a crucial role Unscented Kalman Filter (UKF) plays in the convergence of control and cognition within AI imbued robotics, underlining its pivotal role across a wide range of applications, from navigation and mapping to state estimation and sensor fusion. Our comprehensive analysis, based on a thorough collection and synthesis of contemporary literature, reveals an emerging and changing field, where the merge of control theories, computer vision, and intelligent robotics not only are improving robotic functionality but also opening doors for future innovations. With the help of the bibliometric analysis, the idea of the growing potential of UKF is further emphasized in promoting innovations that erase the border between the robotic control and cognitive processes, thereby leading to the emergence of more autonomous, intelligent, and efficient robotic systems. In addition to this, the study maps the current territory of UKF applications in the robotics and sets the platform for future investigations, targeting the new horizons in the unity of control and cognition.

Declaration

The final draft of this research paper has undergone a rigorous proofreading process, which included the utilization of advanced artificial intelligence (AI) technology.

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