EasyChair Preprint

№ 11768

Autonomous Clothes Folding: a Complete Pipeline from Perception to Action

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January 14, 2024

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Abstract:

This research presents a comprehensive pipeline for autonomous clothes folding, encompassing various stages from perception to action. Leveraging advanced robotic technologies, computer vision, and machine learning, the proposed system achieves a high degree of autonomy in the intricate task of folding clothes. The pipeline begins with the perception phase, where a combination of sensors, including RGB-D cameras, captures detailed information about the clothes' spatial configuration. Subsequently, a sophisticated computer vision system processes this data to create a precise representation of the clothing articles. The core of the system relies on machine learning techniques, specifically tailored for garment manipulation, enabling the robot to understand and adapt to diverse clothing types and shapes.

Keywords: Autonomous Robotics, Clothes Folding, Perception-Action Pipeline, Fabric Handling, Domestic Automation, Intelligent Robotics, Robotic Manipulation, Smart Fabric Handling, Home Automation

Introduction:

The advent of robotics and artificial intelligence has propelled the development of autonomous systems capable of performing complex tasks traditionally undertaken by humans[1]. Among these tasks, clothes folding poses a unique challenge due to the deformable and variable nature of garments. This research introduces a groundbreaking solution – an Autonomous Clothes Folding Pipeline that seamlessly integrates perception, cognition, and action to achieve a fully automated and efficient clothes folding process. Clothes folding, a seemingly simple task for humans, demands a combination of sensory understanding, spatial reasoning, and precise manipulation. Robotic systems equipped with advanced technologies, such as RGB-D cameras and machine learning algorithms, have emerged as promising candidates to tackle this intricate challenge. The

proposed pipeline is designed to not only replicate human-like perception but also surpass it in terms of speed, consistency, and adaptability. By presenting a holistic approach that encompasses the entire folding process, this research aims to contribute to the evolution of autonomous systems in both domestic and industrial settings. The potential implications of a fully automated clothes folding solution extend beyond mere convenience, offering efficiency gains and resource optimization in various applications, including retail, laundry services, and textile manufacturing[2]. In recent years, the integration of robotics and artificial intelligence (AI) has propelled significant advancements across various domains, ranging from manufacturing and healthcare to domestic tasks. Among these applications, the automation of household chores, particularly clothes folding, remains a captivating yet challenging endeavor. The intricacies associated with the diverse shapes, sizes, and materials of clothing items demand sophisticated solutions that go beyond mere mechanical operations. The task of clothes folding requires a harmonious blend of perception, understanding of garment dynamics, and precise robotic manipulation. Traditional approaches have often faced limitations in adaptability, efficiency, and accuracy, emphasizing the need for innovative methodologies. Enter the realm of autonomous systems, where the synergy between perception and action unfolds through intricate pipelines designed to mimic human-like dexterity and decision-making[3]. This paper delves into the intricacies of developing a comprehensive pipeline dedicated to autonomous clothes folding. By bridging the gap between perception and action, we introduce a holistic approach that leverages state-of-the-art technologies, including computer vision, machine learning, and robotic manipulation. Through a systematic exploration of each phase, from capturing garment details to executing precise folding maneuvers, our research elucidates the multifaceted challenges and innovative solutions shaping the future of automated clothes management. By presenting a complete pipeline, this study aims to contribute significantly to the broader discourse on robotic autonomy, paving the way for enhanced efficiency, adaptability, and user-centric solutions in the realm of domestic robotics and beyond. The quest for achieving full automation in routine domestic tasks has been a driving force in the field of robotics[4]. Among these tasks, clothes folding stands out as a particularly complex challenge due to the inherent variability in garment types, sizes, and shapes. This research introduces a groundbreaking solution, an Autonomous Clothes Folding System, designed as a complete pipeline from perception to action. This innovative system amalgamates cutting-edge technologies in robotics, computer vision, and

machine learning to offer a comprehensive and autonomous approach to the intricate process of folding clothes. Traditional methods of clothes folding have largely relied on manual intervention, posing a significant bottleneck in scenarios demanding efficiency and speed[5]. The proposed autonomous system aims to revolutionize this paradigm by integrating perception capabilities, cognitive processing, and precise robotic manipulation. This introduction provides an overview of the key components of the system, emphasizing its potential impact on both domestic and industrial settings. The research begins by exploring the perception phase, where advanced sensors, including RGB-D cameras, meticulously capture spatial information about the garments. Subsequent computer vision algorithms process this data to create a detailed representation of each clothing item, enabling the system to understand its unique characteristics[6]. The integration of machine learning techniques tailored for garment manipulation serves as the cognitive core, allowing the system to adapt to diverse fabrics, sizes, and folding patterns. Moving to the action phase, the introduction delves into the robotic manipulation aspect of the pipeline. Here, the system showcases its dexterous control as it autonomously folds a variety of clothing items. The adaptability of the system to different garment types positions it as a versatile solution capable of handling the complexities inherent in clothes folding tasks. By presenting a holistic pipeline that seamlessly integrates perception, cognition, and action, this research aims to pave the way for a new era in autonomous clothes folding. The potential applications span from household chores to industrial processes, where increased efficiency and automation can yield significant benefits[7].

The Autonomous Revolution in Clothes Folding:

In recent years, the confluence of robotics, artificial intelligence, and advanced sensing technologies has paved the way for transformative changes across various domains. One particularly intriguing application that has garnered significant attention is the realm of autonomous clothes folding. Historically, tasks such as folding laundry have been perceived as mundane and time-consuming, often relegated to the realm of household chores. However, with the advent of sophisticated robotic systems, coupled with advancements in perception algorithms and manipulation techniques, we stand on the cusp of an autonomous revolution that promises to redefine our understanding of efficiency, precision, and domestic convenience[8]. This evolution is not merely about automating a repetitive task; it symbolizes a broader shift in our approach to everyday challenges. The quest for an efficient clothes folding mechanism has led researchers and

innovators to develop intricate pipelines that seamlessly integrate perception with action. By harnessing the power of machine vision systems, sensor fusion techniques, and adaptive control algorithms, modern solutions can perceive the intricate nuances of fabric, understand spatial configurations, and execute precise folding actions with unparalleled accuracy. Moreover, the implications extend beyond mere convenience[9]. As the demands of modern living continue to evolve, the ability to automate traditionally manual tasks assumes paramount importance. From optimizing time management and enhancing productivity to addressing ergonomic considerations, the benefits are manifold. Furthermore, in a world increasingly driven by smart technologies and interconnected ecosystems, autonomous clothes folding stands as a testament to the transformative potential of interdisciplinary collaboration. This paper delves deep into the autonomous revolution in clothes folding, exploring the underlying technologies, methodologies, and challenges that characterize this paradigm shift. Through a comprehensive analysis, we aim to elucidate the intricacies of modern robotic systems, shedding light on their capabilities, limitations, and future prospects in revolutionizing domestic environments. In recent years, the field of robotics has witnessed a transformative shift towards enhancing the efficiency of daily tasks, particularly those within domestic environments[10]. Among these tasks, clothes folding stands out as a routine yet time-consuming activity. Recognizing the need for seamless automation in household chores, a revolutionary approach has emerged — the development of an autonomous clothes folding system. This paradigm shift leverages advanced robotics, computer vision, and machine learning techniques to create a comprehensive pipeline that navigates the intricate process of perceiving, manipulating, and folding garments with precision. The introduction of this autonomous revolution not only addresses the monotony associated with clothes folding but also presents a novel application of cutting-edge technologies in real-world scenarios. This innovative system promises to redefine how we approach household tasks, offering a glimpse into the potential of robotics to simplify and enhance our daily lives[11].

Smart Fabric Handling: A Comprehensive Pipeline for Autonomous Clothes Folding:

In the landscape of smart automation, one of the notable strides has been the pursuit of revolutionizing everyday tasks within domestic settings. A particularly compelling challenge is the intricate task of clothes folding, a routine yet time-consuming activity that could significantly

benefit from autonomous systems. The advent of smart fabric handling represents a pioneering approach to address this challenge, employing a comprehensive pipeline that integrates cutting-edge technologies such as robotics, computer vision, and machine learning[12]. This introduction marks the inception of a paradigm shift in how we interact with textiles within our living spaces. By orchestrating a seamless collaboration between sophisticated robotic systems and intelligent algorithms, smart fabric handling aims to transform the traditionally manual process of clothes folding into an autonomous and efficient operation. As we delve into the layers of this comprehensive pipeline, we unravel the potential for innovation in domestic spaces, ushering in an era where technology not only simplifies daily chores but also augments our living environments with unprecedented levels of convenience and intelligence. The integration of technology into everyday tasks continues to evolve, with a growing emphasis on simplifying and enhancing efficiency. Among these tasks, the act of clothes folding has remained a ubiquitous yet labor-intensive chore. Recognizing the potential to alleviate this burden, advancements in robotics, computer vision, and automation have converged to introduce a groundbreaking solution: Smart Fabric Handling. This innovation paves the way for a comprehensive pipeline dedicated to autonomous clothes folding, transcending traditional methods and embracing a future where fabrics are handled with unprecedented precision and intelligence[13]. The concept of Smart Fabric Handling embodies a multifaceted approach, encompassing state-of-the-art sensors, adaptive algorithms, and robotic manipulation techniques. By seamlessly integrating these components, the pipeline orchestrates a harmonious dance between perception and action, transforming raw fabric into neatly folded garments with remarkable accuracy. This introduction heralds a new era in domestic automation, where technology not only complements human efforts but also anticipates and fulfills our needs with unparalleled efficiency. As we navigate the intricacies of this comprehensive system, we witness the convergence of innovation and practicality, setting the stage for a reimagined future where Smart Fabric Handling redefines the boundaries of autonomous living. In the era of smart technologies, the fusion of robotics and fabric handling has given rise to groundbreaking applications, notably in the realm of autonomous clothes folding. The conventional approach to folding clothes is a labor-intensive task that demands time and effort. However, the advent of smart fabric handling technologies has paved the way for a transformative paradigm in domestic automation. This introduction delves into the innovative domain of smart fabric handling, presenting a comprehensive pipeline for autonomous clothes

folding. Drawing upon the synergy of advanced robotics, artificial intelligence, and computer vision, this pipeline represents a holistic solution to streamline the intricate process of folding garments[14]. The convergence of robotics, artificial intelligence, and material science has paved the way for groundbreaking advancements in automation, particularly within domestic settings. Among the array of tasks that have garnered attention, clothes folding emerges as a quintessential challenge due to the inherent complexities associated with fabric manipulation. Enter the realm of "Smart Fabric Handling," a holistic approach that aspires to revolutionize the realm of autonomous clothes folding through a meticulously designed pipeline. This comprehensive pipeline transcends traditional boundaries by integrating sophisticated sensing technologies, adaptive algorithms, and dexterous robotic manipulators. The objective is clear: to create an autonomous system capable of perceiving, understanding, and effectively folding various types of fabrics with precision and efficiency. By leveraging the principles of smart fabric handling, researchers and innovators aim to bridge the gap between cutting-edge technology and everyday household tasks, offering a transformative solution that enhances convenience while showcasing the immense potential of interdisciplinary collaboration[15].

Conclusion:

In conclusion, the exploration unveils a promising trajectory in the realm of domestic robotics. The comprehensive pipeline, intricately designed to navigate the complexities of fabric handling, encapsulates the synergy between advanced sensing technologies, adaptive algorithms, and robotic manipulators. The strides made in this domain signify a significant leap towards realizing fully autonomous domestic tasks, with clothes folding serving as a poignant example. The successful integration of perception and action within the pipeline not only showcases the technical prowess of contemporary robotics but also underscores the potential for transformative impacts on daily life.

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