On the Application of Egocentric Computer Vision to Industrial Automation

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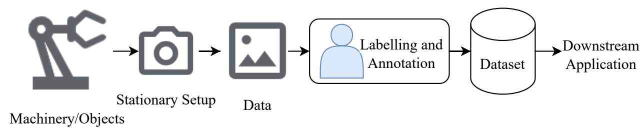
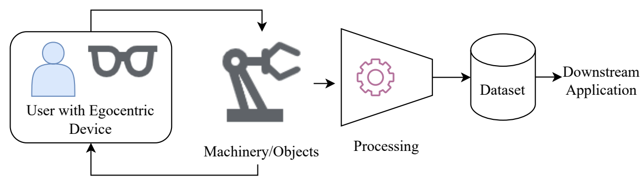
Abstract

Egocentric vision aims to capture and analyse the world from the first-person perspective. We explore the possibilities for egocentric wearable devices to improve and enhance industrial automation w.r.t. data collection, annotation, and labelling. This would contribute to easier data collection and allow the users to provide additional context. We envision that this approach could serve as a supplement to the traditional industrial Machine Vision workflow. Code, Dataset and related resources will be available at: https://github.com/Vivek9Chavan/EgoVis24



(a) The conventional data collection and labelling approach, involving a fixed, stationary setup.



(b) A proposed approach for automated data collection and annotation, where a user describes their observation while interacting with the object. The data is then processed to obtain the labelled dataset.

Figure 1. A comparison of the two approaches. Our work explores the latter.

1. Introduction

The field of Egocentric Computer Vision has seen increased attention in recent years [9, 12]. This has been catalysed due to the increased mainstream focus on wearable Augmented Reality (AR) and Virtual Reality (VR) devices [1, 4]. The Computer Vision community has introduced several novel datasets in recent years, with an aim to unlock and explore new challenges and innovations in this area [2, 7, 8]. These large and diverse datasets capture humans in varying everyday scenarios.

In contrast, we focus on industrial production scenarios. Industry 4.0, or smart manufacturing, focuses on digital transformation of product development, including manufacturing, use, maintenance, and recycling [6]. There is a significant gap between the current state-of-the-art in Artificial Intelligence (AI) and Computer Vision Research, and its integration into traditional production systems [11]. The bottleneck often tends to be the digitisation of workflows and the inability to capture the expertise of the Subject-Matter Experts (SMEs) proficiently.

The conventional exocentric/allocentric data collection in the industry is summarised in Figure 1a, which requires careful labelling, annotation and documentation for training AI models or knowledge transfer. In this ongoing research work, we study the use of lightweight egocentric devices for capturing multimodal egocentric data, which is processed via agentic workflow for adding task relevant labels and contextual information to the tasks. This is shown in Figure 1b and Figure 2.

2. Related Work

Egocentric Computer Vision. Understanding the world from the first-person perspective is intuitive for humans, but poses several challenges for conventional Machine Vision and AI methods [2, 7]. Several iterations and configurations of wearable devices have been proposed [3, 5, 7, 10]. Such devices enable additional user specific data to be captured alongside visual data, such as eye-gaze, hand pose, voice interaction. Several novel datasets and benchmarks have been released in recent years, which introduce new challenges and research directions for the community.

Industrial Machine Vision. Traditional image processing has led to several important advancements in the industry, which is further accelerated by deep learning based

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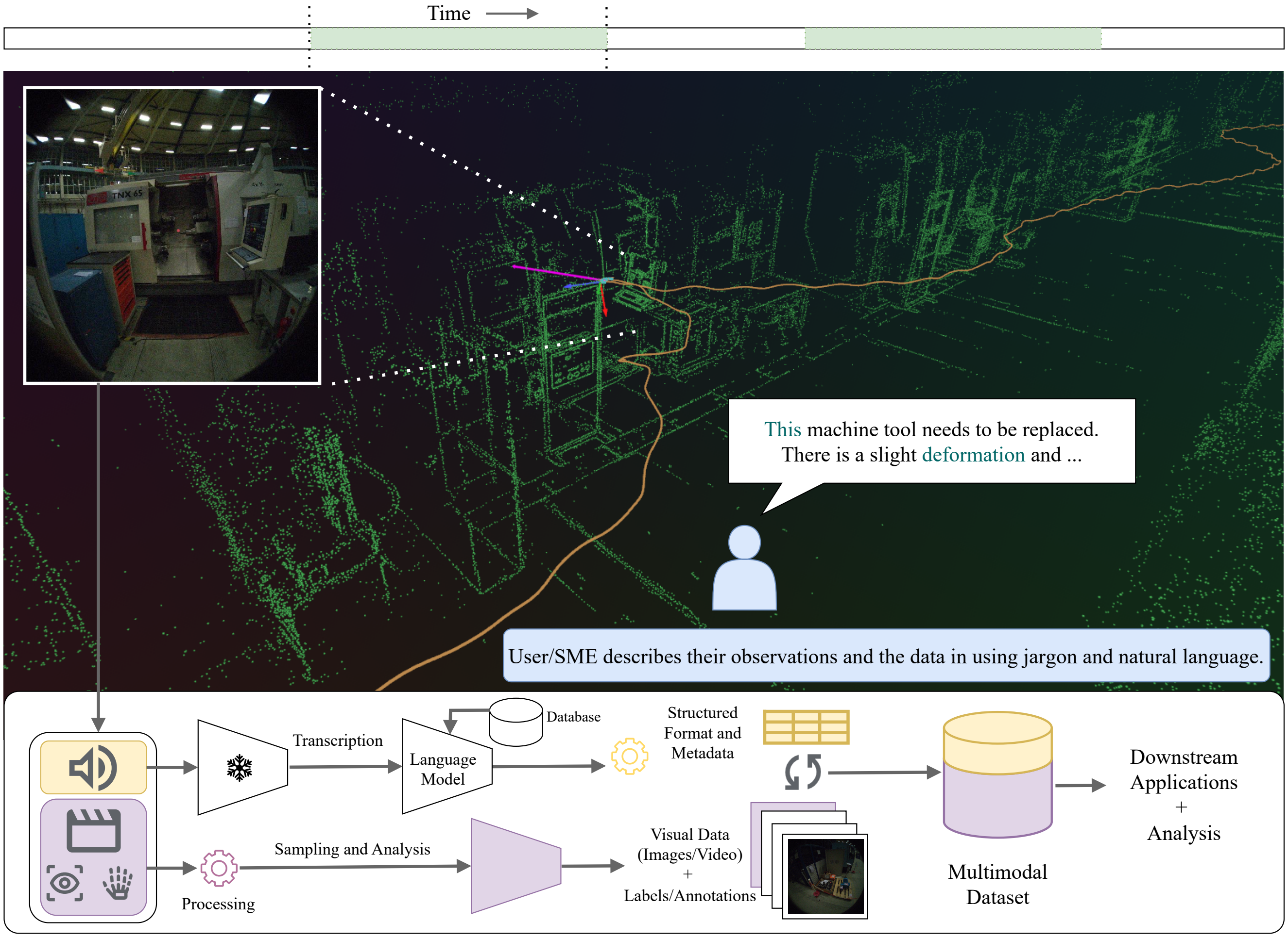

Figure 2. A summary of the proposed pipeline. The User/SME wearing the egocentric device interacts with the object/machinery and documents their observation in natural language. The multimodal dataset is then processed to obtain image/video data, and the transcription, eye-gaze, hand interaction provides the labels and annotations, along with metadata. **Top:** Point cloud reconstruction example from a use case. **Bottom:** A conceptualisation of the data processing.

approaches [11]. The most important areas of application tend to be classification, object detection, segmentation, anomaly/defect detection.

3. Methods

Proposed Pipeline. Figure 2 shows the planned implementation in an industrial setting. We use the Meta Aria glasses [3] as the data capturing device. The multimodal data captured by the user is then processed to extract the most meaningful information about the process, or the machinery. The user guidance via voice serves as the lead indicator for understanding which portion of the continuous stream of the data should be processed. The audio data is processed via a custom language model setup, to obtain structured metadata and labels about the given portion of the stream. The camera stream data, augmented by user interaction (eye-gaze or hands), is processed and synchronised with the audio description data to add annotation and context (e.g. object labels, defects, miscellaneous observations). Additional processed data, such as user trajectory, location and other modalities would also be valuable for adding more context to the captured data.

Challenges. Industrial Machine Vision often requires controlled settings and high precision image processing. Egocentric data capture cannot fully replace standard digitisation stations and setups. In such cases, egocentric data would augment and assist the user in understanding the workflows and operations. Capturing user guidance via voice may be challenging due to noise, presence of other loud voices or perceived discomfort. In such cases, controlling parts of the user input via hand gestures or other means may be valuable. Additionally, capturing user eye gaze, hand gestures and other personal data poses inherent challenges in such cases.

4. Summary

In this extended abstract, we propose an approach for automated data collection and labelling for industrial use cases. The methods and challenges were briefly discussed. This undertaking brings several eccentric benchmarks and tasks, including scene understanding, object detection and tracking, diarisation, action recognition, hand, and eye tracking, among others. We believe such workflows could significantly reduce the efforts required for digitisation and automation, and would improve knowledge transfer between SMEs and trainees, and aid the development of context aware models.

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