Article

Not peer-reviewed version

AI Face-Capture for First-time Passport Application

MD ABDUL BASET SARKER and Masudul H. Imtiaz *

Posted Date: 7 June 2024

doi: 10.20944/preprints202406.0392.v1

Keywords: Pan-Tilt-Zoom (PTZ) Camera; Jetson Processor; Artificial Intelligence (AI); Biometric Capture; Face Detection; Passport Photos; Young Children

Article

AI Face-Capture for First-Time Passport Application

Md Abdul Baset Sarker and Masudul H. Imtiaz *

Department of Electrical and Computer Engineering, Clarkson University, Potsdam, NY 13699, USA; sarkerm@clarkson.edu (M.A.B.S.)

* Correspondence: mimtiaz@clarkson.edu

Abstract: This paper presents the development and implementation of a Pan-Tilt-Zoom (PTZ) camera interfaced with a Jetson processor hosting Artificial Intelligence (AI) algorithms, designed to address the challenges of traditional biometric capture for first-time passport photos of young children. The system enhances the accuracy, efficiency, and adaptability of facial biometric capture by recognizing and accommodating the dynamic and diverse behaviors of children. Utilizing AI, the system detects faces and analyzes facial features using 68 landmark points, ensuring high-quality images that meet ISO standards. These technical specifications, implementation process, and performance evaluations of the developed system are provided in this paper, demonstrating the potential of the proposed AI Face-Capture to advance biometric identification and verification for young children.

Keywords: Pan-Tilt-Zoom (PTZ) Camera; Jetson Processor; Artificial Intelligence (AI); biometric capture; face detection; passport photos; young children

1. Introduction

Capturing passport images of young toddlers can be challenging due to the inherent variability in their facial expressions and movements. Accurate identification is crucial for many security applications, such as preventing human trafficking and border security. Since passport images are the main way that people's identities are verified in biometric systems, their significance must be noticed. Jain et al. [1] state that the stability of collected features is critical to the dependability of biometric systems, and managing active subjects like young infants can provide difficulties in this regard. A specially developed AI camera may address the issue.

Facial recognition technology has witnessed remarkable progress, yet its application to young children presents distinct challenges. The variability in facial structures, rapid developmental changes, and diverse expressions create hurdles for accurate and reliable biometric capture. Traditional facial recognition algorithms often struggle with variability in facial expressions and head movements, which are particularly pronounced in children, as highlighted by Park et al. [2]. This project aims to bridge this gap by devising a custom PTZ-based AI camera system interfaced with a Jetson processor, specifically tailored to cater to the nuanced facial characteristics of young children aged one to five years. This innovation offers promising avenues for more precise and non-intrusive identification and verification, overcoming the limitations of conventional biometric facial capture methods.

In a previous project focused on adult passport photo capture, we implemented 68 landmark points and checked face image quality [3]. During this development, we found that automatic camera adjustment with face position would significantly aid in collecting data from children. The integration of PTZ cameras with AI technology presents a novel approach to overcoming the limitations identified in prior research. Park et al. [4] work on PTZ camera systems highlights their effectiveness in maintaining subject focus and clarity, particularly in environments with significant movement and varying angles. Furthermore, the application of AI for real-time adjustments, as explored by multiple authors [5,6], underscores the potential for such systems to adapt dynamically to changes in the subject's position and lighting conditions.

 doi:10.20944/preprints202406.0392.v1

Camera-based solutions are widely used for various modalities in biometric systems [7–9]. For image analysis-based projects, single-board computers such as Jetson Nano [3,9–11], Google Coral [12,13], and Raspberry Pi [14] are popular for their smaller size and low power consumption. Our study used a Jetson Nano processor with a commercially available camera. The firmware integrates real-time face detection, landmark points algorithms, and dynamic camera control to facilitate automatic face capture from young children in various settings. This innovative system holds significant implications for applications where accurate and non-intrusive biometric identification is paramount, including security systems, childcare monitoring, and educational environments.

The key contributions of this study are:

1. Developed a customized PTZ camera system integrated with AI to capture high-quality passport photos of young children.
2. Designed a complete hardware and software solution for operating with low-power single-board computers.
3. Conducted a validation study with young participants, benchmarking the results against the U.S. government-certified passport image quality website.

2. Methodology

Figure 1 shows the system's block diagram. The Jetson Nano, a compact computing unit, serves as the embedded processor. It directly interacts with the 12MP IMX477 camera to capture the image. A PTZ controller allows control of the connected camera's pan, tilt, and zoom functions so that the system automatically adjusts the subject's slide movement.

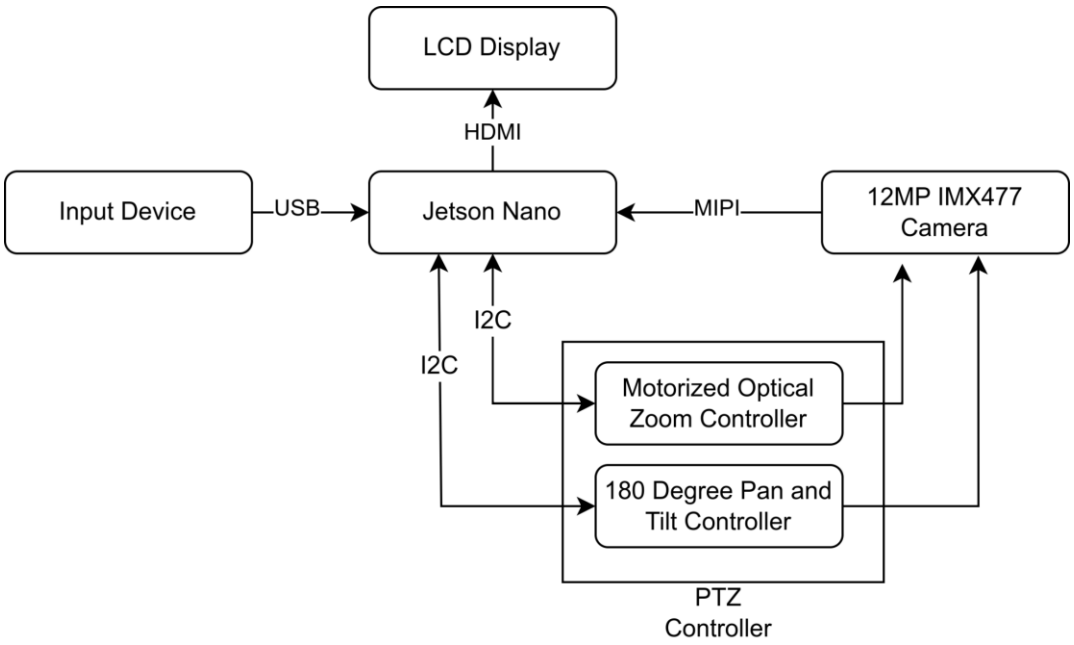

Figure 1. Block diagram of the AI camera setup for capturing passport photo.

Figure 2 shows the flowchart of the system. The system then analyzes this image to locate key facial features like the eyes and nose. Next, a geometric test confirms the arrangement of these features to ensure a valid face is detected. If successful, the system checks the head position and image quality. If these criteria are met, the detected face is displayed on a screen for the user to review and choose. Once selected, the image is stored safely. This process ensures the accuracy of the collected images and user engagement, prioritizing the collection of the best quality facial data. Figure 3 shows PTZ-based AI camera for enhanced face biometric capture system for young children.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 7 June 2024 doi:10.20944/preprints202406.0392.v1

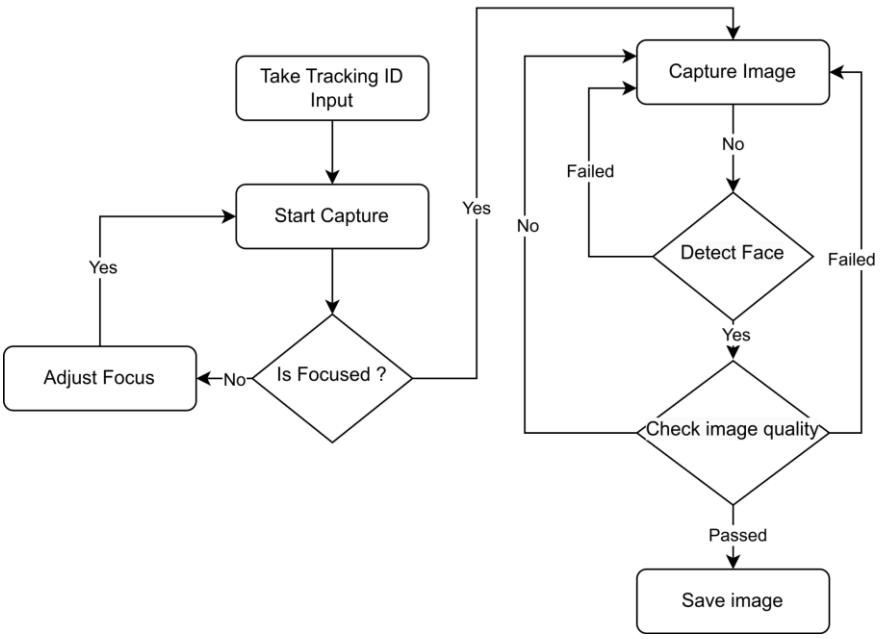

Figure 2. Flowchart of PTZ-based face image capture system for children.

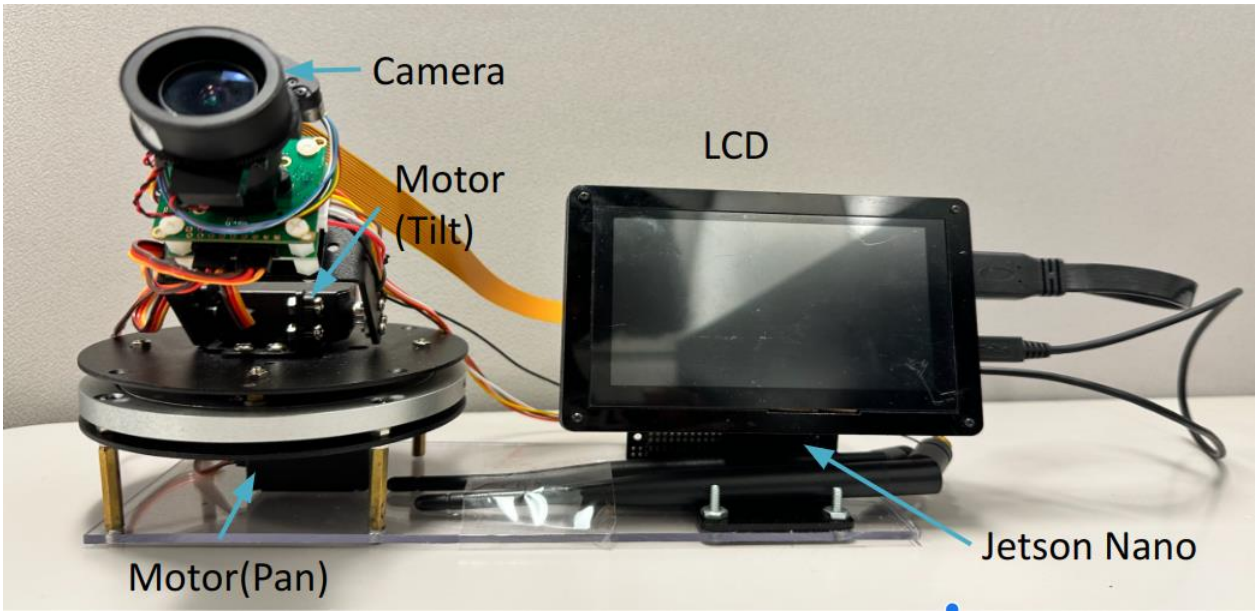

Figure 3. PTZ-based AI camera for enhanced face biometric capture system for young children.

2.1. Hardware

The Jetson Nano 2GB [15] is selected for its powerful AI processing capabilities and compatibility with various peripheral interfaces. It acts as the system's brain, managing the camera operations, executing AI algorithms, and interfacing with other components. A high-resolution 12MP IMX477 camera is integrated via the MIPI interface to capture facial images. The motorized optical zoom controller (Arducam PTZ controller [16]) module adjusts the camera's zoom level to ensure the subject's face occupies an optimal frame portion. 180-degree pan and tilt controller enables the camera to change its orientation dynamically, maintaining the subject's face within the field of view regardless of movement. There are 2317 zoom steps and 3009 focus steps in this system. These features, combined with its wide field of view and optional motorized IR-cut filter, make this camera ideal for applications demanding high-quality visuals, like home security, sun tracking, and wildlife photography. An LCD connected via HDMI provides real-time feedback to the operator, displaying

 doi:10.20944/preprints202406.0392.v1

the captured images and guiding adjustments as needed. An input device, such as a keyboard or mouse, interfaces with the Jetson Nano via USB, allowing user control over system settings and operation.

2.2. Software

The system detects the face using dlib and detects facial landmark points using a 68 landmark points detector [17,18]. After detecting the landmark points, geometric and photographic checks are performed, as denoted in [3]. Under the category of geometric tests, parameters such as eye distance, vertical and horizontal position, head image width, and height ratios are measured to meet specified criteria. Additionally, photographic and pose-specific tests detect blurring, improper lighting, pixelation, red eyes, and various facial expressions or orientations. These comprehensive tests enable the software to identify and rectify potential flaws, ensuring that passport photos adhere to the required standards for accuracy and acceptability. We used this library to control the Arducam PTZ camera [19]. This repository implements the face quality assessment for passport photos [20]. We have adjusted some thresholds and collected data. This project's source code will be in the GitHub repository [21].

3. Result and Discussion

Figure 4 shows that The PTZ camera setup, as depicted in the figure, captures passport photos of a child. The PTZ camera is mounted on a stand, and the design is portable. The camera is directed towards a screen, displaying either a live feed or a captured child image. It also shows the landmark point detection on live feed. This arrangement facilitates precise framing and focus adjustments, which are crucial for meeting the stringent requirements of passport photos. An example of facial landmark point detection is shown in Figure 5.

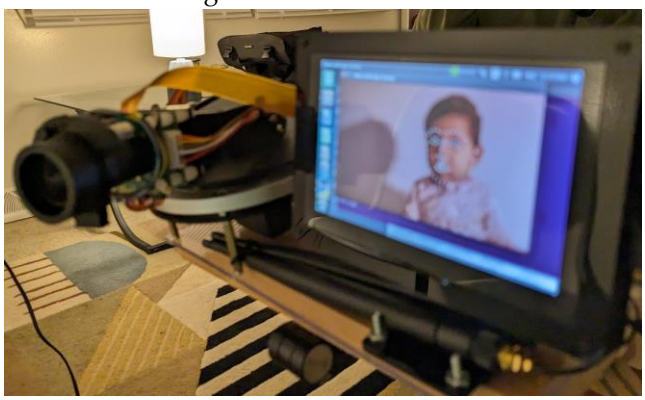

Figure 4. Facial landmark point detection while capturing the image.

Figure 5. An example of facial landmark point detection by the software (eyes blocked because of privacy).

 doi:10.20944/preprints202406.0392.v1

We have collected images from two subjects aged fifteen months and twenty months. Table 1 shows images that were rejected and accepted by the software. We have collected 1280 X 720 pixels images from the participants. After collecting the data, we randomly checked our software-accepted images on U.S. passport check tools [22] and found that 99% of images were also accepted.

Table 1. Collected images using the PTZ system (eyes blocked because of privacy).

Rejected image		Accepted image
		
		

Children, especially the younger ones, have trouble focusing for long periods and are frequently distracted. This can lead to pictures with their eyes closed or their gaze diverted, which is not desired for facial recognition software.

Keeping kids still while taking pictures might be challenging because they are inherently gregarious and lively. Images that are unclear due to movement can further impair facial recognition systems. Having steady, sufficient lighting is essential to getting good portraits of faces. However, illumination can be erratic and unpredictable, particularly in unsupervised settings. Shadows, uneven exposure, and loss of information caused by inadequate lighting can severely impact recognition accuracy.

The system utilizes a strategically positioned camera that automatically adjusts its angle to maintain a natural eye level with the child. This helps engage the child's attention and promotes direct eye contact. The system employs intelligent lighting technology that automatically adjusts the brightness and color temperature based on the ambient light conditions. This ensures consistent and optimal lighting for high-quality image capture. The system provides real-time feedback to the data collector through visual and auditory cues. These cues guide them in achieving optimal positioning, ensuring the child's eyes are open and focused, and maintaining stillness. Additionally, the system can automatically recapture images if they do not meet pre-defined quality standards. One known limitation of the system is that adaptive brightness control is not implemented; it would be a great addition to making a fully automated system. Another system limitation is that the vertical adjustment motor has a limited rotation angle for movement due to the organization. A fully vertically moving system would cover more height.

4. Conclusion

The paper outlines the details of implementing the developed PTZ-based AI camera. Results from preliminary testing demonstrate the system's effectiveness in reliably capturing high-quality

 doi:10.20944/preprints202406.0392.v1

face biometrics of young children in various scenarios. This system's successful implementation and evaluation demonstrate its potential for enhancing security, education, and childcare monitoring applications, providing a reliable and non-intrusive method for biometric identification and verification.

References

1. Jain, A.K.; Ross, A.; Prabhakar, S. An Introduction to Biometric Recognition. *IEEE Trans. Circuits Syst. Video Technol.* **2004**, *14*, 4–20, doi:10.1109/TCSVT.2003.818349.
2. Park, U.; Tong, Y.; Jain, A.K. Age-Invariant Face Recognition. *IEEE Trans. Pattern Anal. Mach. Intell.* **2010**, *32*, 947–954, doi:10.1109/TPAMI.2010.14.
3. Sarker, M.A.B.; Hossain, S.M.S.; Venkataswamy, N.G.; Schuckers, S.; Imtiaz, M.H. An Open-Source Face-Aware Capture System. *Electronics* **2024**, *13*, 1178, doi:10.3390/electronics13071178.
4. Park, U.; Choi, H.-C.; Jain, A.K.; Lee, S.-W. Face Tracking and Recognition at a Distance: A Coaxial and Concentric PTZ Camera System. *IEEE Trans. Inf. Forensics Secur.* **2013**, *8*, 1665–1677, doi:10.1109/TIFS.2013.2261061.
5. Funahashi, T.; Fujiwara, T.; Koshimizu, H. Hierarchical Tracking of Face, Facial Parts and Their Contours with PTZ Camera. In Proceedings of the 2004 IEEE International Conference on Industrial Technology, 2004. IEEE ICIT '04.; December 2004; Vol. 1, pp. 198-203 Vol. 1.
6. Cai, Y.; Medioni, G. Persistent People Tracking and Face Capture Using a PTZ Camera. *Mach. Vis. Appl.* **2016**, *27*, 397–413, doi:10.1007/s00138-016-0758-6.
7. Bingöl, Ö.; Ekinci, M. Stereo-Based Palmprint Recognition in Various 3D Postures. *Expert Syst. Appl.* **2017**, *78*, 74–88, doi:10.1016/j.eswa.2017.01.025.
8. Chowdhury, A.M.M.; Hossain, S.M.S.; Sarker, M.A.B.; Imtiaz, M.H. Automatic Generation of Synthetic Palm Images. In Proceedings of the Proceedings of the Interdisciplinary Conference on Mechanics, Computers and Electrics; Barcelona, Spain, October 6 2022.
9. salih, T.A.; Gh, M.B. A Novel Face Recognition System Based on Jetson Nano Developer Kit. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *928*, 032051, doi:10.1088/1757-899X/928/3/032051.
10. Caracciolo, M.; Casciotti, O.; Lloyd, C.; Sola-Thomas, E.; Weaver, M.; Bielby, K.; Sarker, M.A.B.; Imtiaz, M.H. Autonomous Navigation System from Simultaneous Localization and Mapping. In Proceedings of the 2022 IEEE 31st Microelectronics Design & Test Symposium (MDTS); May 2022; pp. 1–4.
11. Sola-Thomas, E.; Sarker, M.A.B.; Caracciolo, M.V.; Casciotti, O.; Lloyd, C.D.; Imtiaz, M.H. Design of a Low-Cost, Lightweight Smart Wheelchair. In Proceedings of the 2021 IEEE Microelectronics Design Test Symposium (MDTS); 2021; pp. 1–7.
12. Sarker, M.A.B.; Sola, J.P.; Jones, A.; Laing, E.; Sola, E.S.; Imtiaz, M.H. Vision Controlled Sensorized Prosthetic Hand. In Proceedings of the Interdisciplinary Conference on Mechanics, Computers and Electronics (ICMECE); 2022.
13. Park, K.; Jang, W.; Lee, W.; Nam, K.; Seong, K.; Chai, K.; Li, W.-S. *Real-Time Mask Detection on Google Edge TPU*; arXiv, 2020;
14. Sarker, M.A.B.; Imtiaz, M.H.; Mamun, S.M.M.A. Development Of A Raspberry Pi Based Home Automation System. *Bangladesh J. Phys.* **2014**, *16*, 59–66.
15. Get Started With Jetson Nano Developer Kit Available online: https://developer.nvidia.com/embedded/learn/get-started-jetson-nano-devkit (accessed on 27 February 2024).
16. Arducam IMX477 12MP PTZ Camera for Raspberry Pi 4/3B+/3 and Jetson Nano/Xavier NX, IR-Cut Switchable Camera with Metal Base and 2 Digital Servos. *Arducam*.
17. King, D. Dlib: A Toolkit for Making Real World Machine Learning and Data Analysis Applications.
18. Davisking/Dlib: A Toolkit for Making Real World Machine Learning and Data Analysis Applications in C++ Available online: https://github.com/davisking/dlib/tree/master (accessed on 18 August 2023).
19. Lee ArduCAM/MIPI_Camera 2024.
20. Sarker, M.A.B. Baset-Sarker/Face-Image-Quality Available online: https://github.com/baset-sarker/face-image-quality (accessed on 3 June 2024)..
21. Baset-Sarker/Ptz-First-Time-Passport Available online: https://github.com/baset-sarker/ptz-first-time-passport (accessed on 3 June 2024).
22. Photo-Tool Available online: https://tsg.phototool.state.gov/photo (accessed on 18 August 2023).