

## **BAB V**

### **PENUTUP**

#### **V.1 Kesimpulan**

Penelitian ini berhasil merancang sistem PoleArm 1-DOF berbasis multi-scanning untuk pemindaian barcode buku di perpustakaan secara otomatis dan presisi. Sistem menggabungkan lengan robot vertikal dengan motor stepper NEMA 23, kontrol bang-bang, serta limit switch sebagai batas gerak. Deteksi barcode dilakukan secara real-time menggunakan OpenCV dan Pyzbar, dengan dukungan dua kamera (Logitech C270 dan Brio 4K) yang mampu membaca lebih dari satu barcode sekaligus. Pengujian menunjukkan jarak optimal deteksi berada pada 25–30 cm dengan akurasi tinggi. Sistem dikendalikan melalui ROS 2 Humble dan dilengkapi antarmuka UI Python yang memudahkan pengguna. Hasilnya membuktikan sistem ini efektif meningkatkan efisiensi inventarisasi buku dan layak dijadikan prototipe otomatisasi perpustakaan.

#### **V.2Saran**

Penulis memberikan beberapa saran yang diharapkan akan digunakan dalam pengembangan sistem di masa mendatang. Agar kualitas deteksi barcode tetap terjaga, sangat disarankan untuk menggunakan kamera dengan spesifikasi lebih tinggi atau kamera industri dengan fitur autofocus yang lebih cepat. Di sisi perangkat lunak, algoritma pemicu gerakan *PoleArm* dapat dioptimalkan lagi untuk menyesuaikan jeda waktu deteksi sesuai kebutuhan, yang menghasilkan proses pemindaian yang lebih cepat dan efisien. Ke depannya, akan lebih menguntungkan jika sistem ini dapat terintegrasi langsung dengan database manajemen perpustakaan sehingga data hasil pemindaian dapat dicatat secara otomatis tanpa perlu memasukkan input manual. Terakhir, kita dapat mempertimbangkan pengembangan mekanik *Polearm* yang memiliki derajat kebebasan yang lebih besar. Ini akan membuat cakupan pemindaian lebih luas dan lebih fleksibel untuk digunakan dalam berbagai kondisi rak buku.

## DAFTAR PUSTAKA

- [1] X. Shi, K. Tang, and H. Lu, "Smart library book sorting application with intelligence computer vision technology," *Libr. Hi Tech*, vol. 39, no. 1, pp. 220–232, Apr. 2020, doi: 10.1108/LHT-10-2019-0211.
- [2] Y. Rahmanto, D. Alita, A. D. Putra, P. Permata, and S. Suaidah, "PENERAPAN SISTEM INFORMASI PERPUSTAKAAN BERBASIS WEB PADA SMK NURUL HUDA PRINGSEWU," *J. Soc. Sci. Technol. Community Serv. JSSTCS*, vol. 3, no. 2, p. 151, Sep. 2022, doi: 10.33365/jsstcs.v3i2.2009.
- [3] A. A. Fadilah, "Pendidikan Perpustakaan Berbasis Barcode Sekolah Dasar Islam Terpadu Al-Mustofa," vol. 8, 2024.
- [4] S. V. Krishnan *et al.*, "Development of an RFID-Based Semi-autonomous Robotic Library Management System," in *2020 4th International Conference on Automation, Control and Robots (ICACR)*, Rome, Italy: IEEE, Oct. 2020, pp. 26–31. doi: 10.1109/ICACR51161.2020.9265493.
- [5] N. N. Rabiah, L. Lindawati, and S. Sarjana, "Web-Based Laboratory Inventory Application Using QR Code and RFID in Telecommunication Engineering Laboratories/Workshops," *Sinkron*, vol. 7, no. 4, pp. 2248–2261, Oct. 2022, doi: 10.33395/sinkron.v7i4.11624.
- [6] Moch. F. R. Rizaldy, I. Z. Lapi, M. A. Akbar, and P. D. Widayaka, "Inventarisasi Peminjaman Buku Secara Otomatis Pada Perpustakaan Menggunakan RFID Berbasis IOT Via Telegram," *JIPI J. Ilmu Perpust. Dan Inf.*, vol. 8, no. 1, p. 1, May 2023, doi: 10.30829/jipi.v8i1.13843.
- [7] R. Mehta and A. Sahu, "Autonomous Robot for Inventory Management in Libraries," in *2020 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS)*, Bhopal, India: IEEE, Feb. 2020, pp. 1–6. doi: 10.1109/SCEECS48394.2020.18.
- [8] "SISTEM KENDALI PELACAKAN JALUR PADA THREE WHEELED OMNIDIRECTIONAL MOBILE ROBOT BERBASIS PID."
- [9] N. Pradhan, Dr. R. K. Tyagi, and Ms. P. Nagpal, "BARCODE RECOGNITION TECHNIQUES: REVIEW & APPLICATION," *Int. J. Innov. Res. Comput. Sci. Technol.*, vol. 9, no. 3, May 2021, doi: 10.21276/ijirest.2021.9.3.6.
- [10] R. Pawar, P. Korale, B. Khobare, and P. Kasture, "Smart Book Bot: An Autonomous Book Pick and Place Robot for Library Management," vol. 8, no. 2, 2025.
- [11] S. Ahmed, "A Proposed Computer Vision-Based System for Managing the Self-borrowing and Returning Process in Libraries," *Int. J. Libr. Inf. Sci.*, vol. 11, no. 1, pp. 7–30, Jan. 2024, doi: 10.21608/ijlis.2023.239371.1216.
- [12] M. H. K. Saputra, P. Anggraeni, and W. A. Candra, "Optimizing Book Stocktaking Process: Integration of Mobile Robot QRCode Commands with SLiMS," vol. 8, no. 5, 2024.
- [13] N. F. Satria, A. Darmawan, and J. Andika, "Sistem Kendali Mobile Robot Pelempar Bola Berbasis Mobile Application," vol. 10, no. 1, 2024.
- [14] A. R. Chaidir, D. W. Herdiyanto, and G. D. Kalandro, "Pengendalian Mobile Robot Non-Holonomic Berdasarkan Gestur Jari Menggunakan Template

- Matching,” *J. Nas. Tek. ELEKTRO*, vol. 9, no. 1, p. 21, Mar. 2020, doi: 10.25077/jnte.v9n1.741.2020.
- [15] J. Chen, N. Dai, X. Hu, and Y. Yuan, “A Lightweight Barcode Detection Algorithm Based on Deep Learning,” *Appl. Sci.*, vol. 14, no. 22, p. 10417, Nov. 2024, doi: 10.3390/app142210417.
- [16] T. Kamnardsiri, P. Charoenkwan, C. Malang, and R. Wudhikarn, “1D Barcode Detection: Novel Benchmark Datasets and Comprehensive Comparison of Deep Convolutional Neural Network Approaches,” *Sensors*, vol. 22, no. 22, p. 8788, Nov. 2022, doi: 10.3390/s22228788.
- [17] W. Villegas-Ch, A. M. Navarro, and S. Sanchez-Viteri, “Optimization of inventory management through computer vision and machine learning technologies,” *Intell. Syst. Appl.*, vol. 24, p. 200438, Dec. 2024, doi: 10.1016/j.iswa.2024.200438.
- [18] C. Chen and S.-L. Peng, “Multi Barcode Scanning and Decoding Technology Based on AR Smart Glasses”.
- [19] E. Martinez-Martin, “Transforming library operation with robotics”.
- [20] L. H. Pei, “AUTONOMOUS MOBILE ROBOT TRACKING ACROSS MULTIPLE CAMERA VISION”.
- [21] R. Muhammad and F. Hadary, “Performance Analysis of Bang-Bang, Single PID, and Cascade PID Controllers for Cart Pendulum Stabilization”.
- [22] H. K. Kondaveeti, N. K. Kumaravelu, S. D. Vanambathina, S. E. Mathe, and S. Vappangi, “A systematic literature review on prototyping with Arduino: Applications, challenges, advantages, and limitations,” *Comput. Sci. Rev.*, vol. 40, p. 100364, May 2021, doi: 10.1016/j.cosrev.2021.100364.
- [23] A. Abbasimoshaei, M. Winkel, and T. A. Kern, “Design, simulation and evaluation of two coding programming languages for an eye-tracking controlling system for a three degrees of freedom robot useful for paralyzed people,” *E-Prime - Adv. Electr. Eng. Electron. Energy*, vol. 2, p. 100065, 2022, doi: 10.1016/j.prime.2022.100065.
- [24] A. Nurjaman, Afzeri, and N. R. Wibowo, “PEMBUATAN PROTOTIPE ROBOT SCARA DENGAN NEMA 17 DAN PENGONTROL GRBL,” *Ramatekno*, vol. 4, no. 1, pp. 38–46, Apr. 2024, doi: 10.61713/jrt.v4i1.167.
- [25] R. F. Zahrok, S. P. Sakti, and D. Anggraeni, “Rancang Bangun Pengontrol Jarak Menggunakan Motor Stepper Nema 17 Berbasis Mega 2560 Pro pada Ultrasonic Atomizer Spray Coating”.
- [26] E. Damiyanto, I. Nirmala, and T. Rismawan, “Perancangan Tuner Gitar Otomatis Menggunakan Motor Stepper Berbasis Internet of Things,” vol. 13, no. 1, 2025.
- [27] J. Suder, “Parameters evaluation of cameras in embedded systems,” *PRZEGLĄD ELEKTROTECHNICZNY*, vol. 1, no. 9, pp. 218–221, Sep. 2022, doi: 10.15199/48.2022.09.50.
- [28] A. Bonci, F. Gaudeni, M. C. Giannini, and S. Longhi, “Robot Operating System 2 (ROS2)-Based Frameworks for Increasing Robot Autonomy: A Survey,” *Appl. Sci.*, vol. 13, no. 23, p. 12796, Nov. 2023, doi: 10.3390/app132312796.
- [29] M. Guidolin, L. Tagliapietra, E. Menegatti, and M. Reggiani, “Hi-ROS: Open-source multi-camera sensor fusion for real-time people tracking,”

- Comput. Vis. Image Underst.*, vol. 232, p. 103694, Jul. 2023, doi:  
10.1016/j.cviu.2023.103694.
- [30] D. A. Masitah, Ii Munadhif, Adianto, Noorman Rinanto, Ryan Yudha Adhitya, and Khoirul Hasin, “Kontrol Kecepatan Motor Pada Prototype Lift Barang Berdasarkan Berat Beban Menggunakan Metode PID,” *J. Elektron. Dan Otomasi Ind.*, vol. 11, no. 2, pp. 540–550, Jul. 2024, doi:  
10.33795/elkolind.v11i2.5189.
- [31] P. Mingkhwan, S. Sala-ngam, A. Lamom, and C. Photong, “Verifikasi Multiple-Barcode menggunakan Teknik Pemrosesan Gambar untuk Kemasan Ponsel”.
- [32] J. Kevin Vega-Rojas, K. Samuel Andrade-Miranda, A. Justiniano-Medina, C. Alex Alarcon Vasquez, and M. Michael Beraún-Espíritu, “Design and Implementation of an Automated Robotic Bartender Using VDI 2206 Methodology,” *E3S Web Conf.*, vol. 465, p. 02062, 2023, doi:  
10.1051/e3sconf/202346502062.

## LAMPIRAN

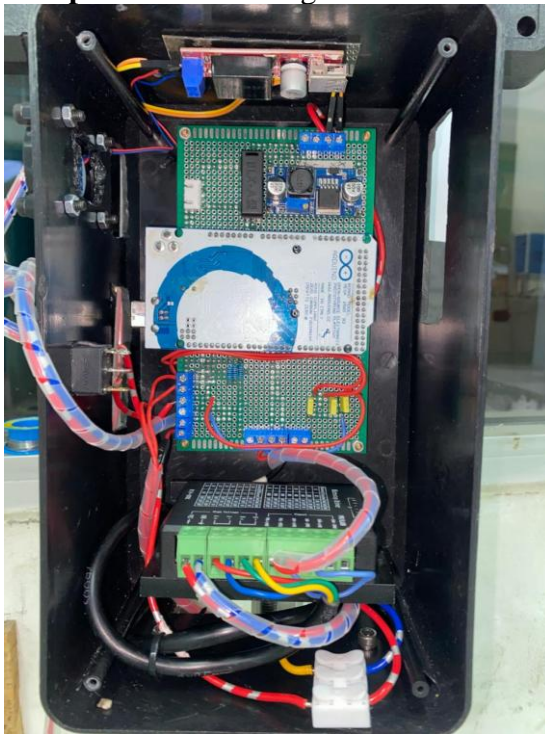
**Lampiran 1** Hasil Integrasi Mekanik *Polearm* Tampak Depan.



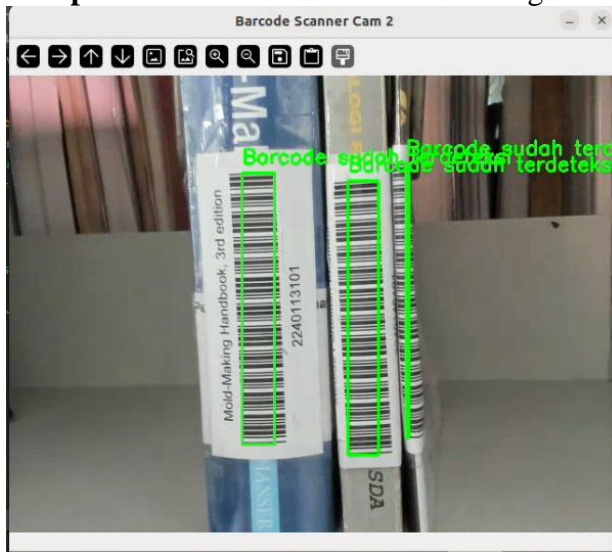
**Lampiran 2** Hasil Integrasi Mekanik *Polearm*, Tampak Belakang.



Lampiran 3 Hasil Integrasi Elektrik *Polearm*.




Lampiran 4 Percobaan Multi-barcode tiga buku



## Lampiran 5 Hasil Integrasi *Dashboard Polearm*

Barcode Detection HMI Dashboard (ROS 2 Connected)

Dashboard Performance Graphs

 **polman** Polearm Barcode Detection

Camera Status: ● Camera 1 ● Camera 2 ● Camera 3 Active Detector: Camera 2

Overall Metrics

**Total Barcodes: 12**

Barcodes / Camera:

- Camera 1: 0
- Camera 2: 12
- Camera 3: 0

Current FPS:

- Camera 1: 0.0
- Camera 2: 0.0
- Camera 3: 0.0

Last Detected Barcode

**2240146101**

Timestamp: 2025-07-13 04:13:37 Duration (s): 0.07

[Start Detection](#) [Stop Detection](#) [Reset Data](#) [Save Log \(CSV\)](#) [Help](#)

Barcode Detection History

Barcode Series	Timestamp	Duration (s)	Camera Source	FPS
2240146101	2025-07-13 04:13:37	0.07	Camera 2	14.7
2240141101	2025-07-13 04:13:37	0.07	Camera 2	14.7
2240111101	2025-07-13 04:13:37	0.07	Camera 2	14.7
2240110101	2025-07-13 04:13:30	0.07	Camera 2	14.2
2240083101	2025-07-13 04:13:30	0.07	Camera 2	14.2
2240081101	2025-07-13 04:13:30	0.07	Camera 2	14.2
2240078101	2025-07-13 04:13:21	0.07	Camera 2	14.7
2240108101	2025-07-13 04:13:21	0.07	Camera 2	14.7
2240089101	2025-07-13 04:13:20	0.07	Camera 2	14.2
2240113101	2025-07-13 04:13:20	0.07	Camera 2	14.2
2240068101	2025-07-13 04:13:20	0.07	Camera 2	14.2

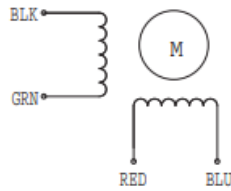
SUCCESS: Barcode '2240146101' detected!

## Lampiran 6 Datasheet Motor Stepper Nema 23

### HIGH TORQUE HYBRID STEPPING MOTOR SPECIFICATIONS

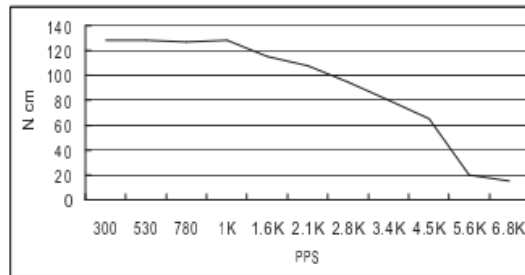
General specifications		Electrical specifications	
Step Angle (°)	1.8	Rated Voltage (V)	3.2
Temperature Rise (°C)	80 Max (rated current, 2 phase on)	Rated Current (A)	2.8
Ambient Temperature (°C)	-20 ~ +50	Resistance Per Phase ( $\pm 10\%$ $\Omega$ )	1.13
Number of Phase	2	Inductance Per Phase ( $\pm 20\%$ mH)	3.6
Insulation Resistance (M $\Omega$ )	100 Min (500VDC)	Holding Torque (N.cm)	189
Insulation Class	Class B	Weight (Kg)	1.05
Max.radial force (N)	75 (20mm from the flange)		
Max.axial force (N)	15		

● Wiring Diagram :

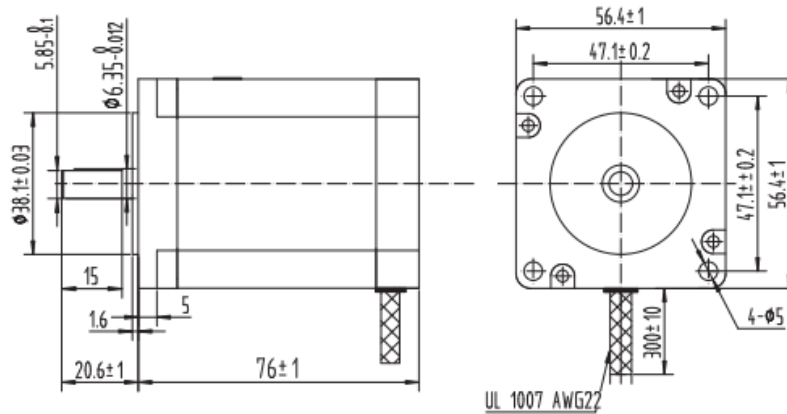


● Pull out torque curve :

VOLTAGE: 30VDC, CONSTANT CURRENT:2.8A,HALF STEP



● Dimensions:  
(unit=mm)



REV	REVISIONS	DESCRIPTION	BY	DATE	SY57STH76-2804A	TECHNICAL CONDITIONS
DRAW	kongxiangzhen	2012.05.16			CHANGZHOU SONGYANG MACHINERY & ELECTRONICS NEW TECHNIC INSTITUTE	080076026
CHECK						
APPROVE						