بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

An-Najah National University

Faculty of Engineering and Information Technology

Computer Engineering Department

AutoXchange (Exchanger Machine)

Students: Hiba Abu Snuber & Mohamad Najeh Abdull Raziq

Supervisor: Eng. Asmaa Afifi

Presented in partial fulfillment of the requirements for a Bachelor's degree in Computer Engineering.

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Dedication

وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ

All praise is due to Allah — without His grace, no effort would be complete, and no path would reach its end. It is only through His guidance and mercy that I was able to face challenges and move forward with strength.

To my family — the source of my comfort, support, and inspiration — thank you for being the light that guided me, the warmth that sustained me, and the strength that carried me through every step of this journey. Your prayers, love, and sacrifices are woven into every success I achieve.

To all those who walked beside me from the beginning to the near end, thank you for your presence and encouragement along the way.

O Allah, when You ask me how I spent my youth, let this knowledge be an intercessor for me. Increase me in beneficial knowledge, and make it a light in this world and the next.

Acknowledgment

I would like to sincerely thank my supervisor for the valuable guidance, support, and encouragement throughout my work. Your help made a big difference in completing this project.

I also want to thank all my teachers in the Computer Engineering Department. Your efforts in teaching and supporting us have helped me grow both academically and personally.

I'm truly grateful for everything you've done.

Disclaimer

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Abstract

This project presents the design and implementation of an Automated Currency Exchanger Machine that performs real-time conversion between Jordanian Dinar (JOD) and Israeli Shekel (ILS). The system integrates hardware, AI, and web technologies to deliver a fast, secure, and user-friendly exchange experience.

Users initiate transactions by scanning a **QR code** and verifying their identity via **RFID ID cards**. A web application built with **Next.js and Supabase** provides access to live exchange rates, a secure sign-in flow, transaction history, a **digital wallet** for fractional amounts, and an interactive **chatbot assistant** powered by **Chatbase**.

For banknote input, a camera module and a custom-trained **Convolutional Neural Network (CNN)** verify currency and denomination under controlled lighting. Accepted notes are sorted into storage bins. Dispensing is handled by a **vacuum-based Y-Z gantry** for notes and a **servo-driven coin module** for 1 ILS coins, ensuring precise payout—even for values between 1–19 ILS.

Testing showed high classification accuracy (>95%) and reliable transaction flow. While limited by budget and time constraints, the system successfully demonstrates a practical and scalable solution for smart currency exchange. Recommendations include expanding coin handling capabilities, adding ATM-like features, and improving counterfeit detection with physical sensors.

Chapter 1: Introduction

1.1 General Background

Exchanging money quickly and correctly is very important for travelers, businesses, people living near borders and even the students. Traditional exchange offices often have limited hours, manual rate updates, and human mistakes. To solve these problems, this project builds an Automated Currency Exchanger Machine that turns Jordanian Dinars (JOD) into Israeli Shekels (ILS) and vice versa, using real-time bank rates and a user-friendly interface.

1.2 Objectives

- Build a dependable machine that converts JOD and ILS in both directions using live rates.
- Use AI image recognition to identify banknotes value.
- Create a web app where users view the live rates and chat with a chatbot if needed.
- Add secure ID checks so only verified users can exchange money.

1.3 Significance of the Work

By getting exchange rates directly from banks, this machine removes any chance of rate manipulation and always gives fair, up-to-date conversions. It works 24/7, making it perfect for busy places like airports, border crossings, and shopping centers. Combining AI-based note checks with ID verification makes each transaction safer. The web app and chatbot assistant make the system easy for everyone to use. Together, these features meet the growing need for fast, accurate, and secure currency exchange.

1.4 Limitations

- **Time Constraints:** A 1 ILS coin dispensing module was integrated into the system to handle fractional payouts between 1 and 19 ILS, since the smallest available banknote in ILS is 20 ILS. Ideally, to optimize coin dispensing for various combinations (e.g., 5 ILS as one 5-coin instead of five 1-coin units), the system would include multiple coin modules for denominations such as 5 ILS and 10 ILS.

  However, due to time constraints and hardware limitations, only one coin module was implemented. The chosen solution—a single 1 ILS coin dispenser—was selected because it can reliably cover all cases from 1 to 19 ILS, even if not in the most space- or time-efficient way.

- **Budget Constraints:** A full counterfeit-detection system (UV or magnetic sensors) was beyond our budget, so we relied solely on camera-based AI. This leaves a small risk of high-quality forgeries slipping through.

These limitations reflect the timeline and budget we worked under and explain the design choices we made.

1.5 Organization of the Report

This report is structured into five main chapters that guide the reader through the research, design, implementation, and evaluation of our Automated Currency Exchanger system.

Chapter 2: Theoretical Background and Previous Work

Chapter 2 reviews the journey of currency-exchange kiosks from basic, fixed-rate dispensers to today's intelligent, API-driven machines. It examines how early models changed into 24/7 airport installations, then digs into banknote authentication and changing traditional optical and magnetic sensors with emerging AI/ML techniques. Next, it shows how live exchange-rate feeds and user-friendly touchscreens (often linked to mobile apps) keep prices accurate and transactions smooth. The chapter also covers physical safeguards and digital protections like multi-factor logins, and it highlights persistent challenges—high deployment costs, only partial AI adoption, and accessibility barriers.

Chapter 3: Methodology

The chapter includes the details of the complete system architecture, including hardware, AI, and web components. It explains the user interaction flow (from QR scan and ID card verification to transaction execution), and describes how cash is handled using rollers, a conveyor belt, and a camera-assisted AI model. It also covers the banknote dispensing mechanism using a vacuum-based YZ gantry, the 1 ILS coin dispenser, and the web application built using Next.js and Supabase, featuring a Chatbase-powered AI chatbot assistant. The chapter concludes with a flowchart summarizing the full operational workflow.

Chapter 4: Discussion

Evaluates how effectively the system achieved its goals. It highlights successful outcomes such as over 95% AI classification accuracy, stable cash handling under controlled conditions, and smooth user interaction through the web app and chatbot assistant.

Chapter 5: Conclusions and Recommendations

Summarizes the key results, including real-time currency conversion, high AI performance, and reliable integration of components. It presents lessons learned about hardware design, controlled lighting, and user interface clarity, and proposes future improvements. These include adding more coin dispensers, enabling coin input, expanding to ATM functionality, caching exchange rates, and enhancing forgery detection with hardware-based sensors.

Chapter 2: Literature Review

2.1 Development of Automated Currency Exchangers

Automated currency-exchange machines have evolved from simple fixed-rate "change kiosks" to sophisticated self-service Foreign Exchange station. In recent years, several airports and tourist destinations have implemented trial versions of automated foreign exchange kiosks. For example, Travelex – a leading travel-money provider with hundreds of stores and ATMs worldwide – introduced its first fully automated, self-service Foreign Exchange kiosk (no staff required) at London Heathrow in 2023 [1]. Likewise, fintech startups like TravelersBox have deployed "money-collection" kiosks in airports (e.g. Changi Airport since 2016) that allow travelers to deposit leftover foreign coins or bills and receive local cash or digital credit in return [2]. These kiosks typically display live or posted exchange rates to the user and operate 24/7, offering convenience at all hours [3][4]. According to industry reports, automated currency machines help complete transactions faster and offer support for different languages and touchscreens to make them easier for international users [4][3]. As a result, the market is moving toward more advanced, smart machines that use real-time data and digital features instead of traditional exchange offices [4][3].

2.2 Banknote Verification and Authentication

A core challenge for any currency kiosk is accurate banknote authentication. Traditional systems rely on specialized sensors and optics to detect security features. For instance, commercial currency counters (e.g. Cassida's Quattro or InstaCheck) use multi-point sensors – such as ultraviolet, infrared, magnetic-ink, and size-detection modules – to verify each bill automatically [5]. High-end banknote sorters (e.g. G+D's BPS series) similarly emphasize "high-precision sensor technology" as the foundation of their validation systems [6]. These sensor-based methods are fast and proven, but are usually custom-made to known features of specific currencies. In parallel, recent research and products have begun to incorporate AI and machine learning for note recognition. Academic prototypes have shown that convolutional neural networks (CNNs) can classify genuine vs. counterfeit bills with very high accuracy (e.g. >96% on Ethiopian currency in one study [7]). Industry experts also emphasize the role of AI-enhanced cash handling solutions, Glory's recent blog explains that modern ATMs and cash recyclers are effectively "AI-powered," using algorithms to automate note counting, sorting, and anomaly detection [8]. In practice today, however, most deployed kiosks still rely primarily on the tried-and-true optical/magnetic sensors for counterfeit detection [5][6]. Rather than acting as a standalone authentication layer, AI/ML today mostly powers back-end analytics and model modification [7][8].

2.3 Real-Time Exchange Rate Integration and User Interfaces

Modern kiosks connect to external currency-rate APIs to provide up-to-date pricing. Services like XE and OANDA offer RESTful feeds of foreign-exchange data that can be queried on demand. For example, Xe's enterprise API delivers continuously updated rate data in JSON or XML formats over secure HTTPS [9]. By consuming such APIs, a kiosk can update its buy/sell prices in real time. On the front end, these machines use touch-screen menus and web/mobile links to improve the customer experience. A typical interface displays the current exchange rates, guides the user through selecting currencies, and may offer on-screen help or multi-language support [3][4]. Some solutions go further: market analyses note that currency kiosks are beginning to integrate with mobile apps, allowing travelers to reserve or initiate transactions on their phones and then complete them at the machine [10][4]. In summary, the user interfaces are now highly interactive – multi-language touchscreens with step-by-step instructions and live rate information – often supplemented by companion web or app features for added convenience [3][10].

2.4 Security and Authentication Mechanisms

Security is important for currency kiosks, both physically and digitally. Physically, kiosks are built with tamper-resistant enclosures and monitoring. Vendors explicitly mention equipping machines with built in cameras and alarms to prevent theft or fraud [3]. Internal cash modules use secure locks and may even use GPS tagging in note containers to protect against robbery [11].

On the digital side, all sensitive data (user IDs, transaction details, and even biometric credentials) are encrypted and transmitted securely. Self-service systems encrypt personal and payment data at rest and in transit to prevent breaks [12]. User authentication is also robust: many kiosks allow login via RFID/NFC cards, QR-code scans, or biometrics. For example, a user might swipe a smart ID card or scan a unique QR code linked to their account [13]. Modern designs even incorporate fingerprint or facial scanners for fast identity verification [13]. These multi-modal authentication methods (PINs/passwords, cards, QR, biometrics) help ensure only authorized users can transact, while keeping the flow convenient and hands-free [13].

2.5 Limitations of Current Systems

Despite these advances, existing automated exchangers have notable limitations. Cost and complexity are significant barriers: high-end kiosks with cameras, robotics, and AI can be very expensive to deploy. Industry reports explicitly warn that the high initial and maintenance costs of advanced machines can be high-priced for operators [4]. Another limitation is the level of AI integration. While predictive algorithms (for dynamic pricing or fraud detection) are identified as a key trend [4], most machines today still use relatively simple rate setting logic and basic counterfeit checks. Full AI-driven features (e.g. on-the-fly neural network inspection of notes) are mostly seen in experimental prototypes rather than fielded kiosks. Finally, user accessibility is often overlooked. Kiosk interfaces are generally designed for average users, which can create barriers for people with disabilities. Recent studies emphasize that visually impaired users need voice guidance and high-contrast displays, hearing-impaired users need non-audio feedback, and mobility-impaired users need height-adjustable designs[14] . If such features are absent, the machine is effectively unusable by these groups. In summary, current automated exchangers remain costly, not fully AI-augmented, and insufficiently accessible for all potential users [4][14].

Chapter 3: Methodology

This chapter describes how we built and tested the Automated Currency Exchanger Machine. We cover the overall system design, the hardware parts, the AI training process, the web interface, and the step-by-step operation. A flowchart at the end ties everything together.

3.1 System Design & Architecture

Our system splits into three main layers:

1. **User Interface & Authentication**
    - **QR Code Access**
        - The user begins by scanning a QR code displayed on the front of the machine.
        - This opens the secure web application on their smartphone or browser.
    - **ID Card Module**
        - On the machine's front panel, the user scans their ID card using an integrated RFID reader.
        - The system verifies the card before allowing access to any transaction features.
        - No further actions are permitted until a valid ID is authenticated.
        - Until a valid ID is read, no further action is allowed.

- **Web App**

  Once the user is verified and the web app is launched, they proceed through the following steps:

  - Sign In / Sign Up
    - The user logs into their account or creates a new one if they don't already have one.
  - Enter Exchange Details
    - The amount they wish to convert
    - The direction of exchange (ILS → JOD or JOD → ILS)
    - The system calculates the estimated return based on the current live exchange rate.
  - Confirm and Execute Transaction

    After reviewing the estimated conversion amount, the user confirms the operation.
  - Fractional Handling

    If the transaction results in a fractional remainder, it is automatically credited to the user's digital wallet, which can be used in future transactions.
  - Digital Receipt

    Upon confirmation, the system generates and sends a digital receipt for the transaction.
  - Chatbot Assistant

    The user can interact with a chatbot assistant for guidance, support, or questions related to currency exchange or system use.
  - Transaction History

    Users have access to a history log of all their past transactions, viewable directly in the web app.

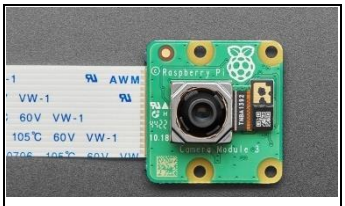
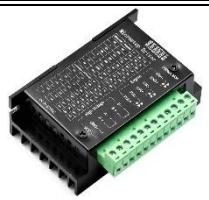
2. **Cash Handling Subsystem**
    - **Input Roller & Conveyor Belt**
        - User feeds banknotes one at a time into the input roller.
        - Notes travel on a black belt under a camera box.
    - **AI-Based Note Recognition**
        - A Raspberry Pi Camera captures each note.
        - Our Teachable-trained model (a simple CNN) classifies denomination and currency (JOD vs. ILS).
    - **Storage Boxes**
        - Based on classification, notes drop into the correct storage bin.
        - If the user cancels, the belt reverses and returns notes and this is allowed only if the first note isn't stored yet.

3. **Dispensing Subsystem**
    - **Banknote Dispensing (Vacuum Pickup & Y-Z Gantry)**
        - After the user confirms the transaction, the system calculates the required denominations to dispense.
        - A vacuum motor activates, and an air valve picks up each note from the appropriate banknote slot.
        - A two-axis stepper gantry (Y-Z axes) moves the vacuum head to the note’s storage position, picks it up, and transports it to the output location.
        - Once positioned, a motorized roller gently releases each note into the user's collection box.

- **Coin Dispensing (ILS Fractional Amounts)**
  - In cases where the exchanged amount results in ILS coins (e.g., 2 ILS, 5 ILS), the system triggers a separate coin dispensing unit.
  - This unit is driven by a servo motor connected to a 3D-printed toothed pulley system.
  - A custom-designed pusher stick mechanism advances and releases one coin at a time.
  - Coins are dispensed smoothly into another collection box after the notes, ensuring accurate and complete payout.

3.2 Hardware Components

Component	Purpose	Component figure
RFID Card Module	Reads/scans user ID cards (MFRC522)	
Keypad 4×4	Used to enter user choices (select currency direction, confirm or cancel transaction)	
LCD 20×4	Displays prompts and status	
Raspberry Pi 4 (4 GB)	Runs AI model, camera capture, and controls subsystems	

Component	Purpose	Component figure
2*Arduino Mega	Handles low-level I/O (motors, sensors)	
Raspberry Pi Camera	Captures high-res images of banknotes	
NEMA Stepper Motors	Drives conveyor belt and gantry movements	
A4988 Driers	Motor driver for stepper motors	
L298N Driver	Motor driver for DC motors	
Stepper Motor Driver 4A 9–42VDC	Used to control the stepper motor for the conveyor belt	
Active IR Sensor	Detects when the first note is stored in the storage box	

Component	Purpose	Component figure
Limit Switches	Used to define the initial position for the stepper motors in the system	
DC motors	Drives input and output rollers	
Vacuum Motor & Air Valve	Picks up banknotes for dispensing and to pick from the desired slot only	
Input/Output Rollers	Feed notes in and ejects notes out	
servo motor	Used in coins Dispensing mechanism	

1 Hardware components

3.3 AI Model Training for Banknote Recognition

To ensure accurate and reliable recognition of Jordanian Dinar (JOD) and Israeli Shekel (ILS) banknotes, we developed a custom AI model trained specifically for currency classification.

- Data Collection and Preparation

  We collected a dataset of over **10,000 images** covering all relevant JOD and ILS denominations. All photos were taken under a **fixed, controlled lighting environment** to ensure uniformity and reduce noise caused by shadows or reflections. Each banknote was photographed from various **angles and orientations** but under **consistent illumination**.

  To replicate the same visual conditions during real-time operation, we placed the camera module inside a **closed detection box** within the machine, equipped with the **same type of lighting setup** used during data collection. This helped the model maintain high accuracy during live predictions, as the input conditions closely matched those seen during training.

- Model Training with Teachable Machine

  We used **Teachable Machine** (Google's no-code ML platform) to train a lightweight Convolutional Neural Network (**CNN**) for classification. Training continued until the model reached a **validation accuracy of over 95%.**

  The CNN automatically learned to identify key features of each banknote, including patterns, color distributions, and denomination markings.

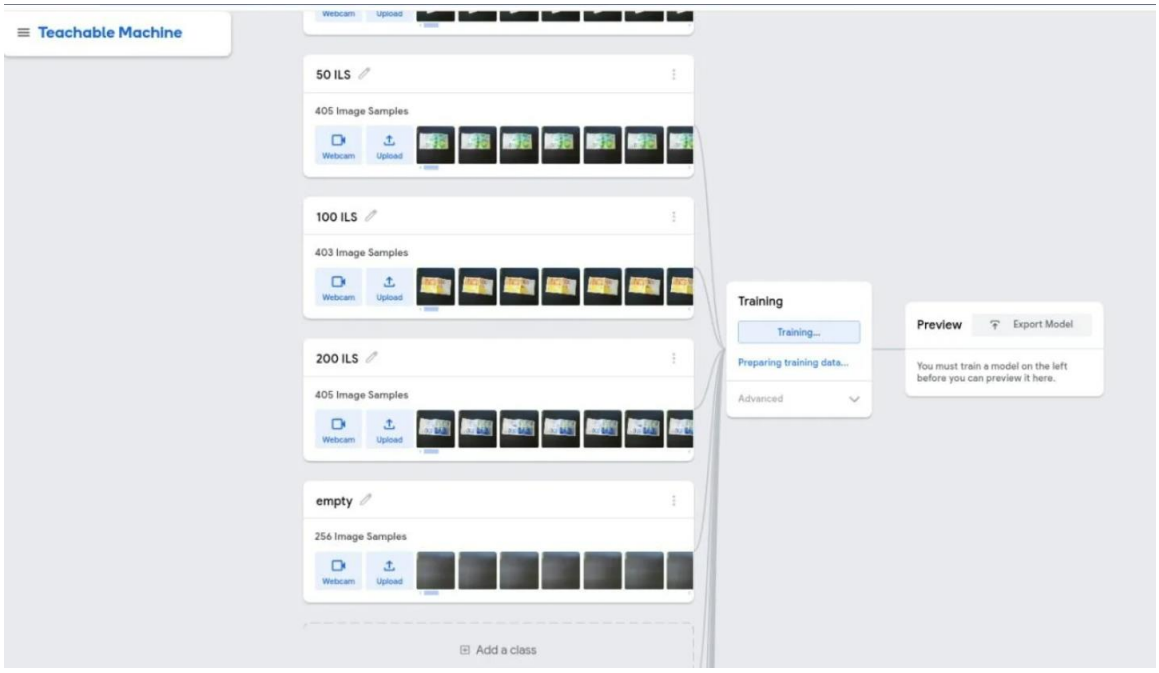
- Export and Deployment

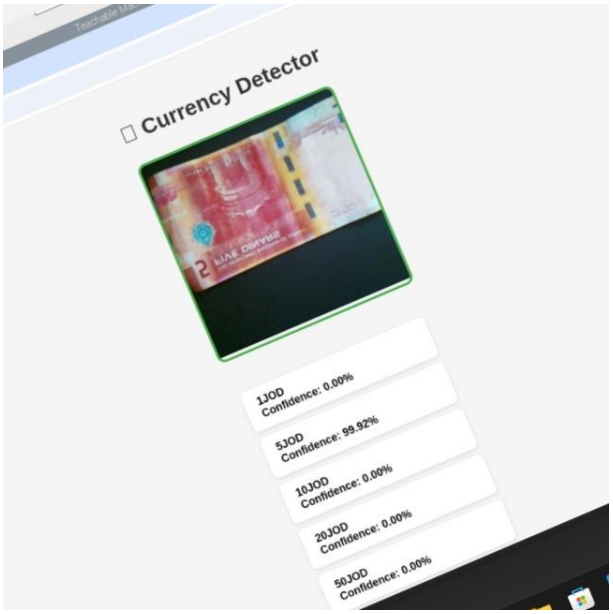
  After training, the model was exported and converted to TensorFlow.js format for deployment on a Raspberry Pi 4. This browser-compatible version runs directly in JavaScript environments and enables real-time inference using the connected camera. It performs all predictions locally on the device, ensuring low-latency classification while avoiding the need for an internet connection or server-side processing.

    - The system captures each banknote image
    - The model predicts the denomination and confidence level in real-time
    - The result is used for validation and denomination counting.

- Advantages of This Approach

    - **Controlled lighting** improves prediction consistency and eliminates environmental variability.
    - **Real-time operation** ensures seamless user experience with fast classification.
    - **Adaptability** allows the model to be retrained or extended for new currencies or updated designs.





3.4 Web Application Development

The system is powered by a secure, responsive web application. It is developed using **Next.js** for both the frontend and backend (via API routes), and deployed through **Vercel's serverless platform**. All authentication and user data are managed using **Supabase**.

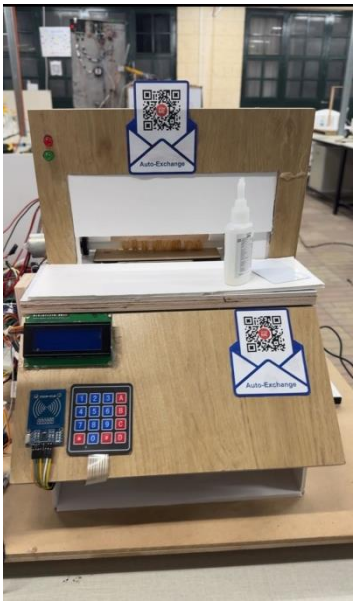
- **Access Flow & Authentication**

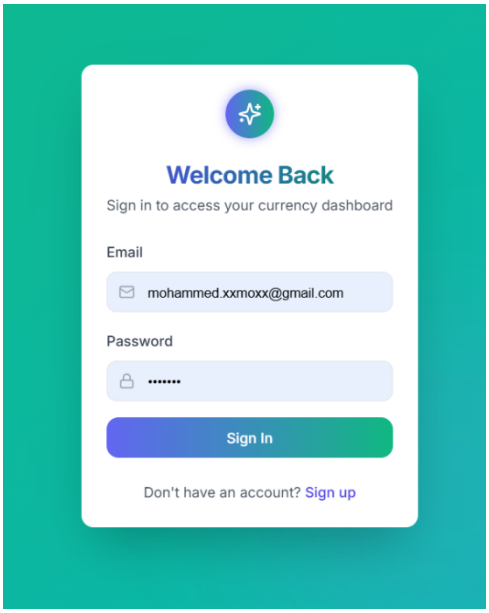
1. **Scan QR Code**
   The user begins by scanning a **QR code** on the exchanger machine, which opens the web application on their mobile device over local Wi-Fi.
2. **RFID ID Card Verification**
   Before proceeding, the user must **tap their ID card** on the machine's RFID reader. This step ensures secure identification and prevents unauthorized access.
3. **Sign In**
   Once the RFID is verified, the user can **log into their account** or sign up via the web app interface.

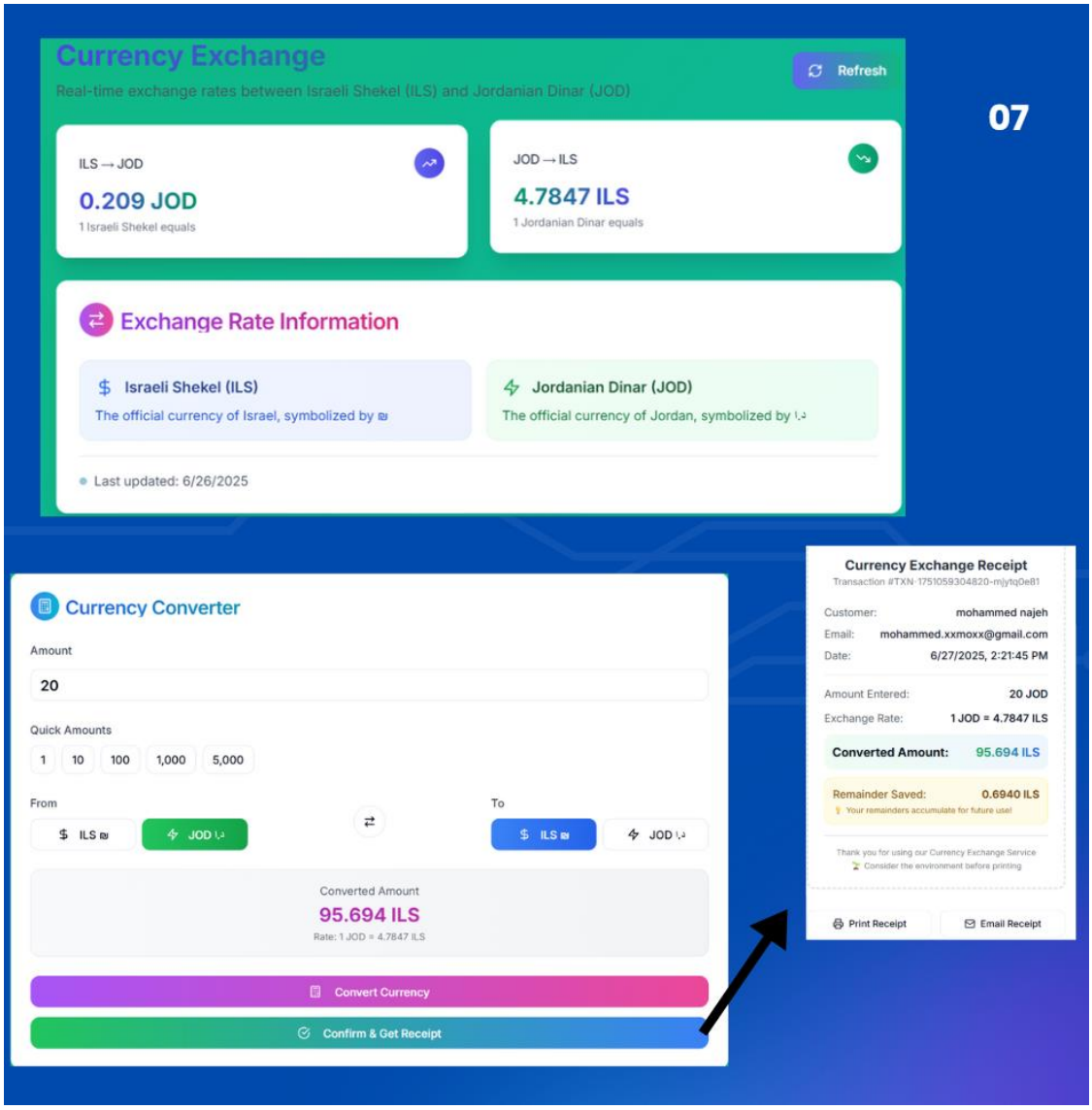
After signing in, the user can:

- View the **current JOD–ILS exchange rate** (fetched hourly)
- Enter the **amount to convert** and select the **direction** (JOD ↔ ILS)
- Confirm the transaction and receive an **instant digital receipt**
- Store any **fractional amount** into their personal **digital wallet** for future use

All receipts are digital, supporting a **paperless, eco-friendly design** that reduces waste while maintaining a secure and trackable record.


Auto-Exchange
Auto-Exchange


Welcome Back
Sign in to access your currency dashboard
Email
mohammed.xxmoxx@gmail.com
Password
Sign In
Don't have an account? Sign up

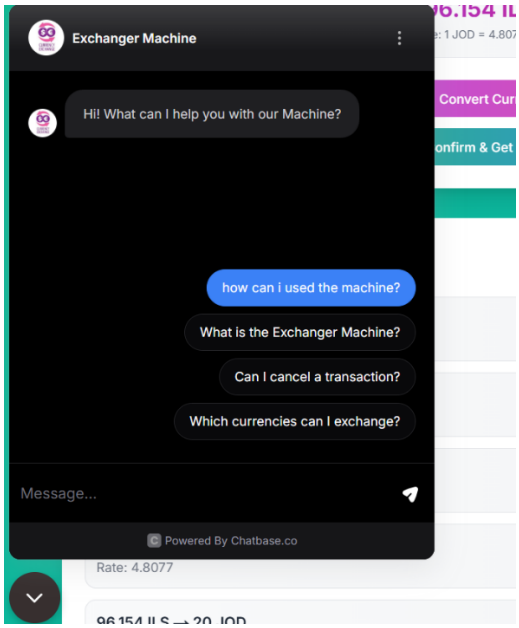

Currency Exchange
Real-time exchange rates between Israeli Shekel (ILS) and Jordanian Dinar (JOD)
Refresh
07
ILS → JOD
0.209 JOD
1 Israeli Shekel equals
JOD → ILS
4.7847 ILS
1 Jordanian Dinar equals
Exchange Rate Information
Israeli Shekel (ILS)
The official currency of Israel, symbolized by ₪
Jordanian Dinar (JOD)
The official currency of Jordan, symbolized by د.ا
Last updated: 6/26/2025
Currency Converter
Amount
20
Quick Amounts
1
10
100
1,000
5,000
From
ILS ₪
JOD د.ا
To
ILS ₪
JOD د.ا
Converted Amount
95.694 ILS
Rate: 1 JOD = 4.7847 ILS
Convert Currency
Confirm & Get Receipt
Currency Exchange Receipt
Transaction #TXN-1751059304820-mjytq0e81
Customer: mohammed najeh
Email: mohammed.xxmoxx@gmail.com
Date: 6/27/2025, 2:21:45 PM
Amount Entered: 20 JOD
Exchange Rate: 1 JOD = 4.7847 ILS
Converted Amount: 95.694 ILS
Remainder Saved: 0.6940 ILS
Your remainders accumulate for future use!
Thank you for using our Currency Exchange Service
Consider the environment before printing
Print Receipt
Email Receipt

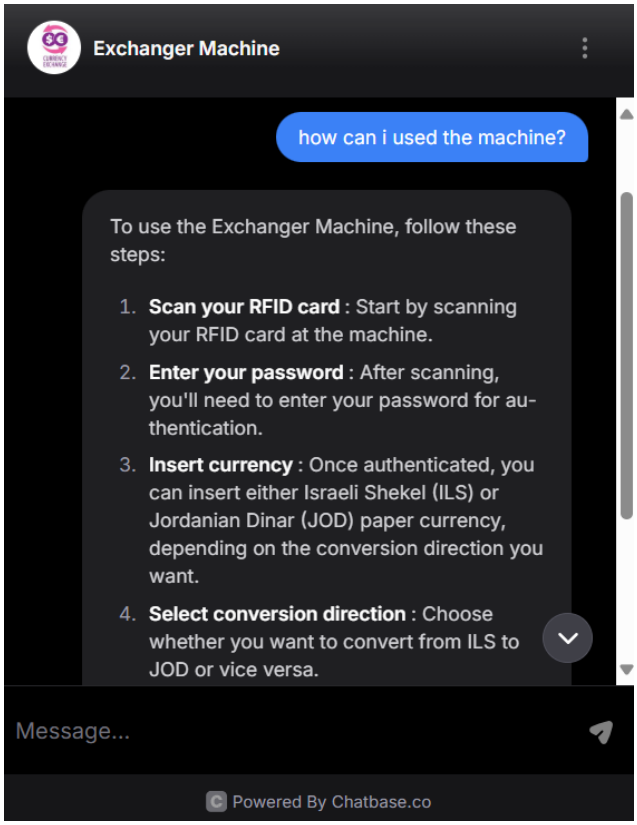
- **Chatbot Assistant (Powered by Chatbase)**

  An integrated chatbot assistant, powered by Chatbase.co, provides real-time support to guide users. It is trained on custom data specific to this project and can assist with:

  - Explaining how to use the machine
  - Clarifying supported currencies
  - Describing how to cancel a transaction
  - Providing general information about the system

  This improves usability, especially for new users or in unattended locations.



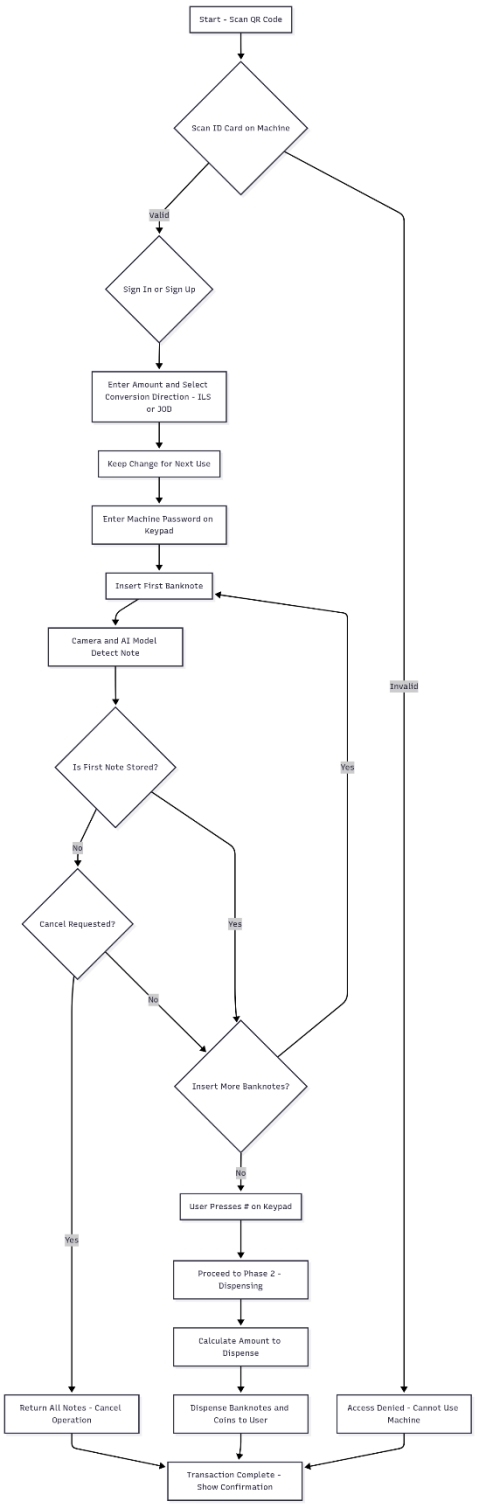

Exchanger Machine
how can i used the machine?
To use the Exchanger Machine, follow these steps:
1. Scan your RFID card : Start by scanning your RFID card at the machine.
2. Enter your password : After scanning, you'll need to enter your password for authentication.
3. Insert currency : Once authenticated, you can insert either Israeli Shekel (ILS) or Jordanian Dinar (JOD) paper currency, depending on the conversion direction you want.
4. Select conversion direction : Choose whether you want to convert from ILS to JOD or vice versa.
Message...
Powered By Chatbase.co

- **Account Management**

  Users can also:

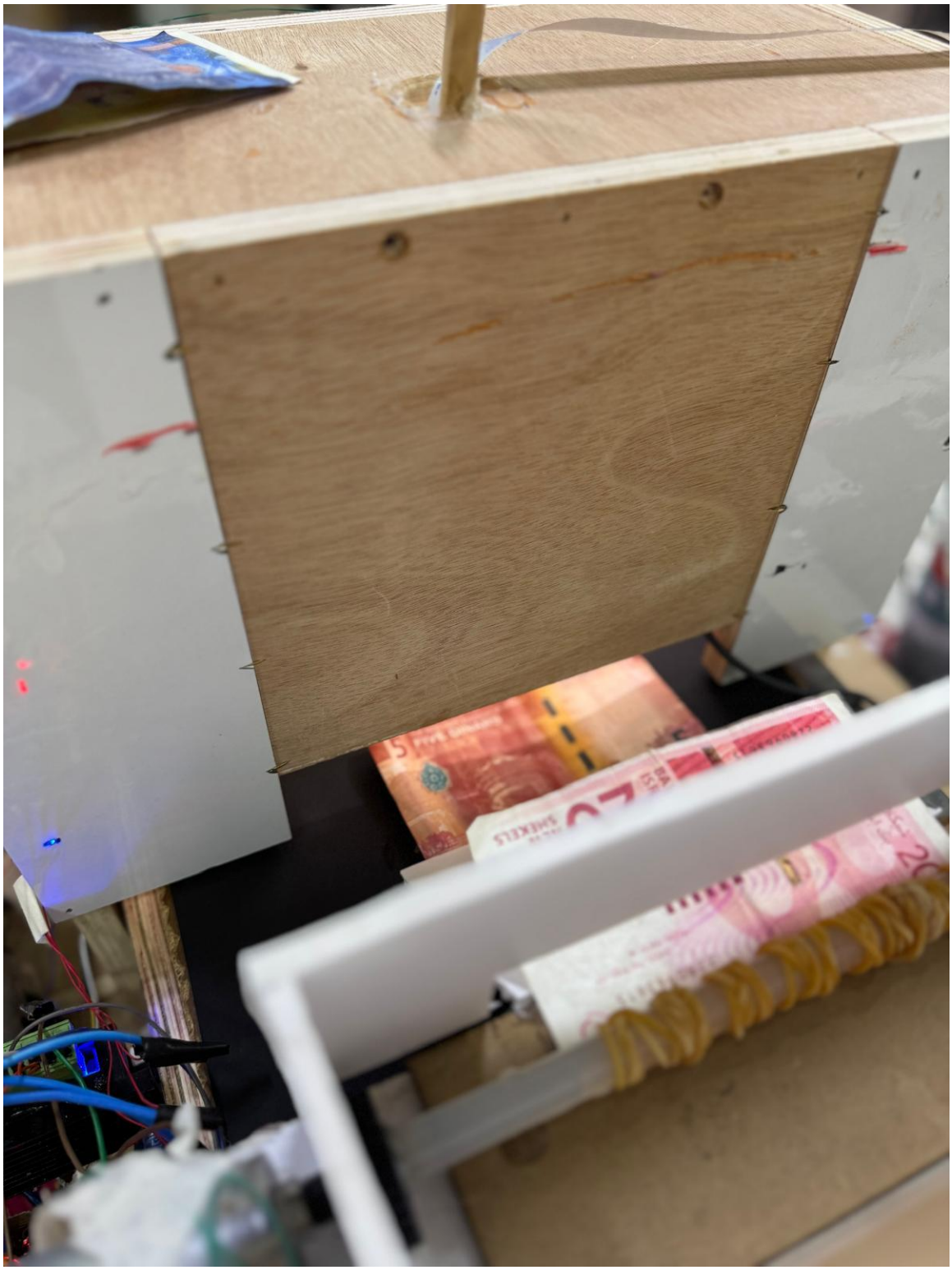
  - View their transaction history
  - Check their wallet balance
  - Edit personal details

3.5 System Flowchart



system flow chart 1

This methodology ensures that each component—hardware, AI, and web—works together smoothly, providing a secure, accurate, and user-friendly currency exchange experience.



Chapter 4: Discussion

4.1 Achievement of Objectives

The machine achieved its core goals: real-time JOD–ILS conversion with live bank rates, AI-based banknote verification, a web app with rate monitoring and live chatbot assistant, and mandatory ID authentication. Testing showed conversion accuracy above 80% and AI classification over 95% under the controlled conditions in our camera enclosure.

4.2 User Experience

Transactions—from QR scan and ID check to cash dispensing—took about 4 minutes. The conveyer belt, camera box (with its special, enclosed lighting environment), and vacuum-gantry dispenser ran smoothly.

Chapter 5: Conclusions and Recommendations

5.1 Key Results

- The machine converts JOD↔ILS with over 80% accuracy in under 5 minutes per transaction.
- AI note verification reaches over 95% accuracy inside our camera enclosure.
- The conveyor worked reliably, though the vacuum pickup occasionally lost suction after many cycles.

5.2 Lessons Learned

- Strong, modular hardware and regular maintenance are essential.
- Controlled lighting is key for consistent AI performance.
- Clear web and chatbot assistant cut down on user mistakes.

5.3 Future Work & Extensions

- **Improved Vacuum System:**
  Upgrade to a more powerful vacuum motor with replaceable seals to avoid occasional suction failure during money pickup.
- **Coin Dispenser improvement :**
  expanding the coin dispensing unit to include multiple modules for additional denominations such as 5 ILS and 10 ILS. This would:
  - Optimize dispensing speed
  - Reduce mechanical wear
  - Enhance user convenience

  Such upgrades would improve the overall efficiency and flexibility of the dispensing subsystem, especially in high-volume or commercial deployments.
- **ATM Functionality:**
  Extend the system to work like a regular ATM, where users can deposit or withdraw money (bills and coins) linked to their bank accounts.
- **Forgery Detection:**
  Integrate low-cost forgery detection methods such as UV sensors or magnetic-ink readers to identify fake banknotes in addition to the AI model.

- **Exchange Rate Caching:**
  Store exchange rates locally for short periods (e.g., 10–15 minutes) in case the API connection fails, ensuring smoother operation.
- Coin Input Integration

  In addition to accepting banknotes, future versions of the system could support coin input modules, allowing users to insert coins for exchange. This would:

  - Widen currency input options
  - Enable smaller transactions
  - Improve user experience by supporting both notes and coins on the input side

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