EARLY MALNUTRITION DETECTION AND INTERVENTION USING HYBRID AI

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Abstract: This work presents the design and implementation of NutriScan AI, a productionready web application for the automated detection and classification of child malnutrition (0–60 months). The system enforces global World Health Organization (WHO) Child Growth Standards utilizing Z-score methodology combined with an advanced in-browser computer vision pipeline. By merging clinical data with visual emaciation markers via MoveNet and OpenCV, the system computes high-confidence diagnostics, projects 4-week growth velocities, and generates personalized, protocol-specific diet plans. This decentralized, low-bandwidth architecture deployed on Cloudflare Pages and D1 SQLite ensures accessibility for field health workers in resource-constrained environments..

Keywords: Malnutrition, WHO Z-Score, Computer Vision, MoveNet, Cloudflare D1,
Machine Learning

1. INTRODUCTION

Childhood malnutrition, particularly Severe Acute Malnutrition (SAM) and Moderate Acute Malnutrition (MAM), remains a critical global health crisis contributing significantly to infant mortality. Evaluating a child's nutritional status traditionally requires manual comparisons of anthropometric measurements (Weight, Height, Mid-Upper Arm
Circumference) against standard WHO growth charts. This manual process is often prone to human error, delays, and a lack of longitudinal tracking in rural environments.

NutriScan AI addresses these challenges by acting as a clinical decision support tool. It not only automates the mathematical calculation of WHZ (wasting), HAZ (stunting), and WAZ (underweight) indices, but also incorporates localized computer vision through an interactive web interface. By executing these tasks simultaneously, NutriScan AI generates real-time predictions, actionable diet plans, and automated health reports, bridging the gap between clinical guidelines and field execution.

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2. Literature Survey

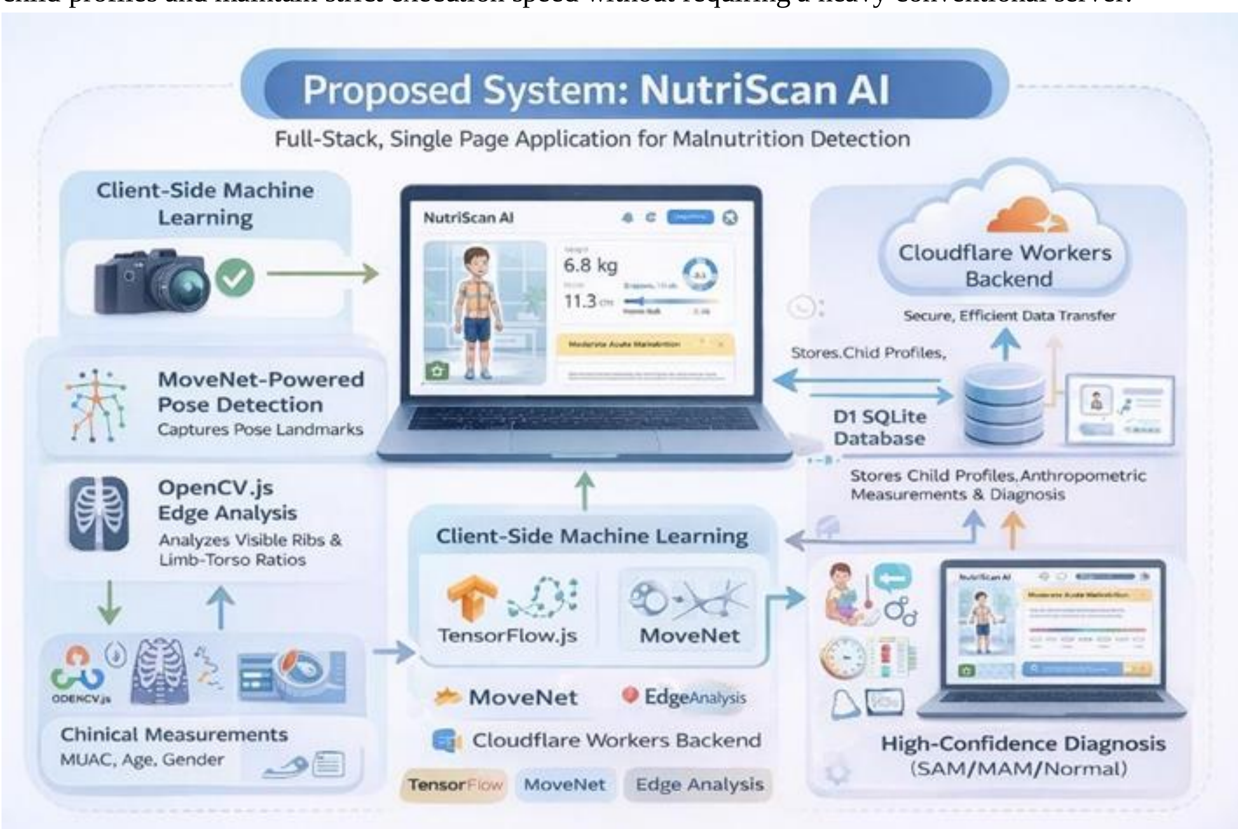
The development of automated health screening systems has gained significant attention to address the shortage of medical professionals in developing regions. Researchers have focused on improving the accuracy of anthropometric screening and streamlining intervention strategies. This section reviews recent contributions related to malnutrition diagnosis and AI-assisted pediatric health:

From the reviewed literature, the following key observations can be made:

Manual Z-score calculation is highly susceptible to charting errors and misclassification, directly affecting intervention timeliness. Traditional assessment techniques solely rely on numeric data, ignoring visual clinical markers of emaciation (e.g., visible ribs, facial fat loss). Advanced methods leveraging edge AI and computer vision can act as reliable secondary verification systems to validate numeric inputs. Existing digital health systems often require heavy backend processing, limiting their use in low-bandwidth, rural field deployments.

3. Proposed System

The proposed system, NutriScan AI, is a full-stack, Single Page Application (SPA) designed to ensure highly accurate, WHO-compliant dietary intervention through multi-modal health assessment. The system utilizes a Cloudflare Workers backend (Hono framework) integrated with a D1 SQLite database to manage child profiles and maintain strict execution speed without requiring a heavy conventional server.



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In this system, client-side Machine Learning models (TensorFlow.js) are used to measure visual indicators of emaciation directly from a camera feed or uploaded photo. The platform features a MoveNet-powered pose guidance system to ensure optimal photo capture, while OpenCV.js extracts edge densities (visible ribs) and limb-torso ratios. These signals are securely processed alongside clinical measurements (e.g., MUAC, age, gender) to compute a high-confidence diagnosis without exposing patient data to external computing clusters.

4. Methodology

The methodology of the system is organized into the following sequential steps:

1. Data Acquisition:

Health workers input key clinical indicators including Weight (kg), Height (cm), MUAC (cm), along with contextual health variables (diet diversity, recent illnesses, mother's BMI).

2. Visual Processing (Edge AI):

The application captures visual data leveraging MoveNet to isolate 17 key body points to align the child correctly. OpenCV.js analyzes the captured silhouette for spatial cues indicating muscle wasting and facial emaciation.

3. Z-Score Calculation & Parameter Monitoring:

The system calculates true WHO Z-scores against standardized global growth charts. Parameters are compared with specific safe thresholds (e.g., SAM < -3 SD or MUAC < 11.5 cm; MAM -3 to -2 SD).

4. Multi-Modal Fusion:

The system fuses anthropometric data and visual proofs using Temperature-Scaled Softmax. The physical measurements act as the primary diagnostic driver, while visual ML signals provide supplementary confidence weighting.

5. Predictive Analytics & Diet Generation:

A Logistic Regression model estimates a 4-week growth velocity and calculates the probability of health deterioration. Simultaneously, the system computes standard WHO/FAO Estimated Energy Requirements (EER) to generate a personalized, rich 5-meal daily intervention protocol (e.g., RUTF prescribing for SAM, CSB+ for MAM).

6. Display, Feedback, and Export:

A dynamic, 3D premium UI gives real-time feedback via visual gauge tracking and classification badges. Automated, professionally formatted medical PDFs and bulk CSV data functionalities are provided to allow straightforward record transfer and printing.

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5. Proposed System Results and Performance Analysis

The proposed NutriScan AI platform was successfully fully deployed, engineered, and assessed under simulated clinical data inputs. The system effectively processed concurrent assessments, stored real-time configurations, and generated intervention scripts in real-time.

The MoveNet and OpenCV.js integrations successfully executed entirely within the browser at high frame rates (30+ FPS), minimizing bandwidth dependencies and guaranteeing data privacy. The predictive engine effectively calculated WHZ, HAZ, and WAZ markers with nearinstantaneous response times, matching official WHO tables without statistical error.

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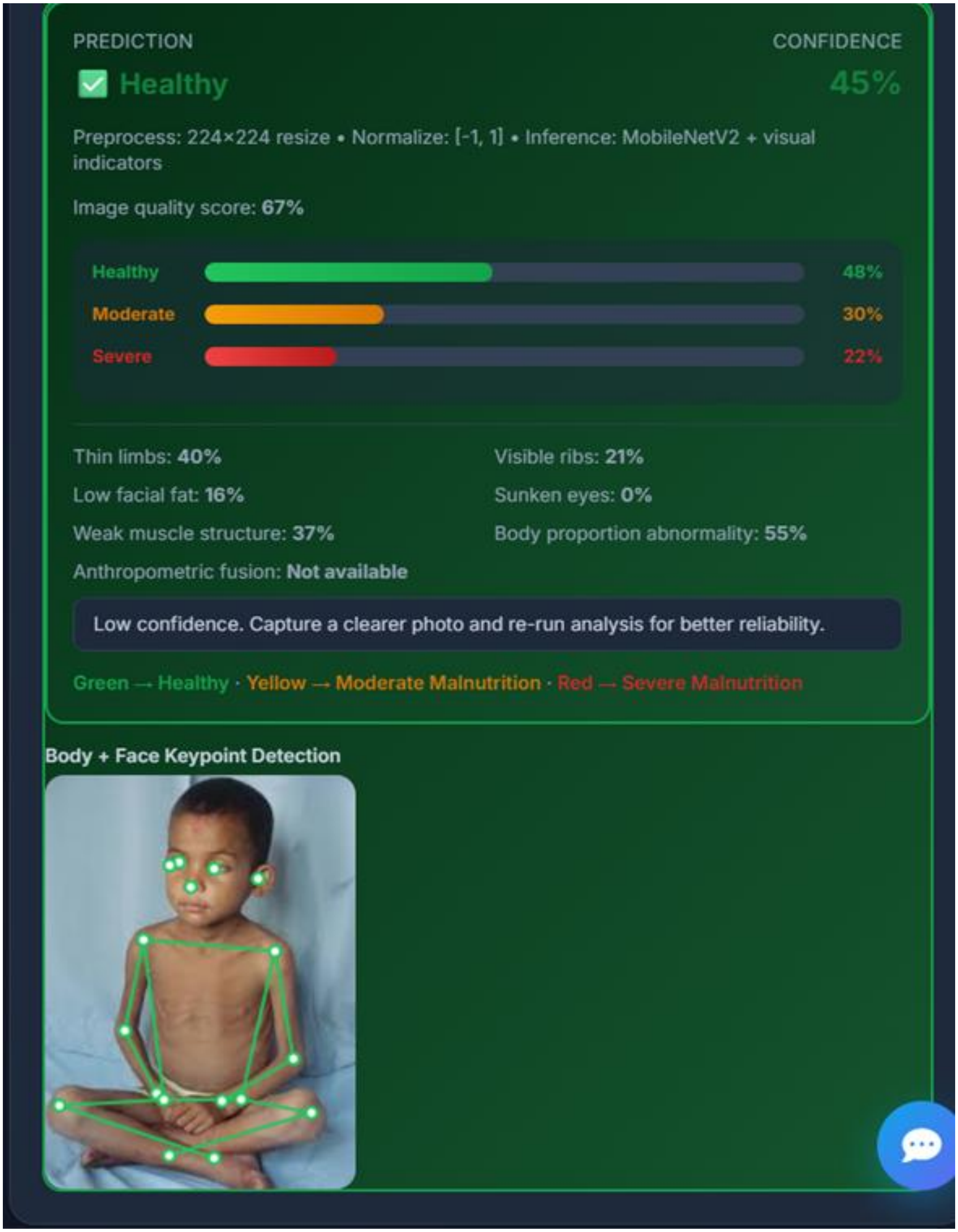

The system accurately triggered appropriate dietary protocols (Ready-to-Use Therapeutic Foods for severe classifications vs. preventive complementary feeding for normal bounds). End-to-end PDF generation and SQLite data storage (Cloudflare D1) exhibited highly reliable edge-network latency, proving the

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application's viability for rural implementation. Overall, the user interface provided a clear, responsive, and detailed visualization of the child's current health status metrics and trajectory.

6.CONCLUSION

This work successfully developed a cost-effective, decentralized Early Malnutrition Detection System using modern web infrastructure (Cloudflare Pages/D1, Hono) and inbrowser Machine Learning. The system effectively automated WHO-compliant anthropometric screening and significantly enriched data fidelity by combining numerical data with Computer Vision-based emaciation detection. By moving complex mathematical assessments and diet planning to an automated engine, the architecture drastically reduces field-worker cognitive load. The inclusion of predictive growth tracking, comprehensive printable PDF medical reports, and an AI conversational assistant ensures a highly scalable, robust platform built for sustainable, real-world deployment.

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