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REVIEWER'S REPORT

Manuscript No.: **IJAR-53323** Date: **15.08.2025**

Title: Intelligent Dual-Leg Wearable for Early Arthritis Screening via Gait Analysis and On-Device Machine Learning

Recommendation:
Accept after minor revision………………

Rating	Excel.	Good	Fair	Poor
Originality	✓			
Techn. Quality		✓		
Clarity		✓		
Significance		✓		

Reviewer Name:Dr.K.Arumuganainar **Date: 15.08.2025**

Reviewer's Comment for Publication.

Recommendation: **Minor Revision** (for a conference/journal submission at prototype stage)

- The work is technically sound, relevant, and novel.
- Needs **more experimental validation** to strengthen claims.
- Minor improvements in clarity and additional testing would make the work more robust for publication.

Detailed Reviewer's Report

Review Report

Title

"Intelligent Dual-Leg Wearable for Early Arthritis Screening via Gait Analysis and On-Device Machine Learning"

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1. Summary of the Paper

The paper presents the design, development, and initial evaluation of a **low-cost, dual-leg wearable device** that uses **bilateral knee-mounted accelerometers** and **on-device machine learning (TinyML)** to classify gait patterns into three categories: *No Arthritis*, *Moderate Arthritis*, and *Major Arthritis*.The system streams real-time data via **Bluetooth Low Energy (BLE)**, provides **multimodal biofeedback** (vibration, buzzer, LED), and aims to support **at-home screening and rehabilitation** for arthritis patients.

A **proof-of-concept pilot study** demonstrated:

- **Stable bilateral gait sensing**
- **Real-time inference with 89.8% accuracy**
- Feasible biofeedback for self-management

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2. Strengths

- **Novelty & Relevance**: Integrates gait sensing, embedded classification, and biofeedback into a single wearable—addressing gaps in current arthritis monitoring solutions.
- **Low-Cost & Accessibility**: Uses affordable components (Arduino Nano 33 BLE, ADXL335 accelerometer) and 3D printing for enclosures.
- **On-Device Processing**: Eliminates dependency on external servers, improving privacy and reducing latency.

- **Detailed Methodology**: Includes product design, calibration process, machine learning training pipeline, and performance metrics.
- **Real-Time Biofeedback**: Immediate, multimodal cues promote corrective gait changes.
- **Strong Literature Review**: Cites relevant works on gait analysis, wearable devices, and biofeedback.

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3. Weaknesses / Limitations

- **Small Pilot Dataset**: Limited number and diversity of participants reduce generalisability.
- **Sensor Limitation**: Uses accelerometers only—no gyroscope or pressure sensor data for richer gait features.
- **Single Walking Context**: Tested mainly in controlled indoor settings; lacks outdoor and varied surface testing.
- **Model Ambiguity**: Adjacent class misclassifications (Moderate vs Major) remain high due to overlapping gait patterns.
- **No Longitudinal Data**: Lacks evidence on device performance over extended periods and progressive arthritis changes.

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4. Originality & Contribution

The device combines:

1. **Bilateral knee-level sensing** (rare in consumer wearables)
2. **On-device arthritis severity classification**
3. **Immediate, multimodal gait correction feedback**
4. **Low-cost, open, and customisable design**

   This integrated approach is **innovative** and can potentially enable **early arthritis detection at home**, reducing reliance on clinical facilities.

5. Methodology & Analysis Quality

- **Design & Development**: Clearly describes component selection, enclosure design, PCB layout, and firmware functions.
- **Calibration Process**: Well-documented multi-step alignment and synchronisation ensures signal reliability.
- **Data Collection & ML Pipeline**:
  - 2–4s window segmentation with 50% overlap
  - Feature extraction (RMS, variance, cadence, frequency)
  - Training using Google Tiny Motion Trainer with augmentation
  - Quantisation for microcontroller deployment
- **Performance Metrics**: Reports accuracy, precision, recall, F1-score, and confusion matrix analysis.
- **Validation**: Appropriate for a prototype stage but lacks large-scale trials.

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6. Clarity & Organisation

- **Well-structured**: Introduction, related works, methodology, results, and conclusions are logically arranged.
- **Figures & Diagrams**: Clear product images, block diagrams, calibration graphs, and confusion matrix enhance understanding.
- **Readable Language**: Technical terms explained well; some sentences are long and could be more concise.

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7. Suggestions for Improvement

1. **Expand Dataset**: Include more participants across age, gender, arthritis severity, and walking conditions.
2. **Add More Sensors**: Incorporate gyroscopes or foot pressure sensors for richer gait analysis.
3. **Outdoor Testing**: Evaluate performance on varied terrains and speeds.

4. **Model Refinement**: Explore feature selection and hybrid models to reduce confusion between adjacent severities.
5. **Longitudinal Trials**: Test device performance over weeks/months to assess reliability and responsiveness to rehabilitation.
6. **Battery Optimisation**: Provide detailed battery life statistics under continuous operation.
7. **Ethics & Data Privacy**: Add a section on ethical considerations and data security for at-home use.

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8. Overall Recommendation

Recommendation: **Minor Revision** (for a conference/journal submission at prototype stage)

- The work is technically sound, relevant, and novel.
- Needs **more experimental validation** to strengthen claims.
- Minor improvements in clarity and additional testing would make the work more robust for publication.

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9. Overall Evaluation

Criterion	**Score (out of 5)**
Originality	4.5
Technical Quality	4.0
Clarity of Presentation	4.0
Practical Relevance	4.5
Experimental Validation	3.5
Overall	**4.1**