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Paper Title: Embedded AI for Intelligent Wildfire Monitoring: A Multi-Sensor and Vision-Driven Approach

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Challenges of Traditional Fire Detection

The occurrence of fires in urban and rural landscapes is a persistent challenge. Quick response to fires can save lives, properties, and natural resources

Cost

Current technologies are expensive and of complex maintenance.

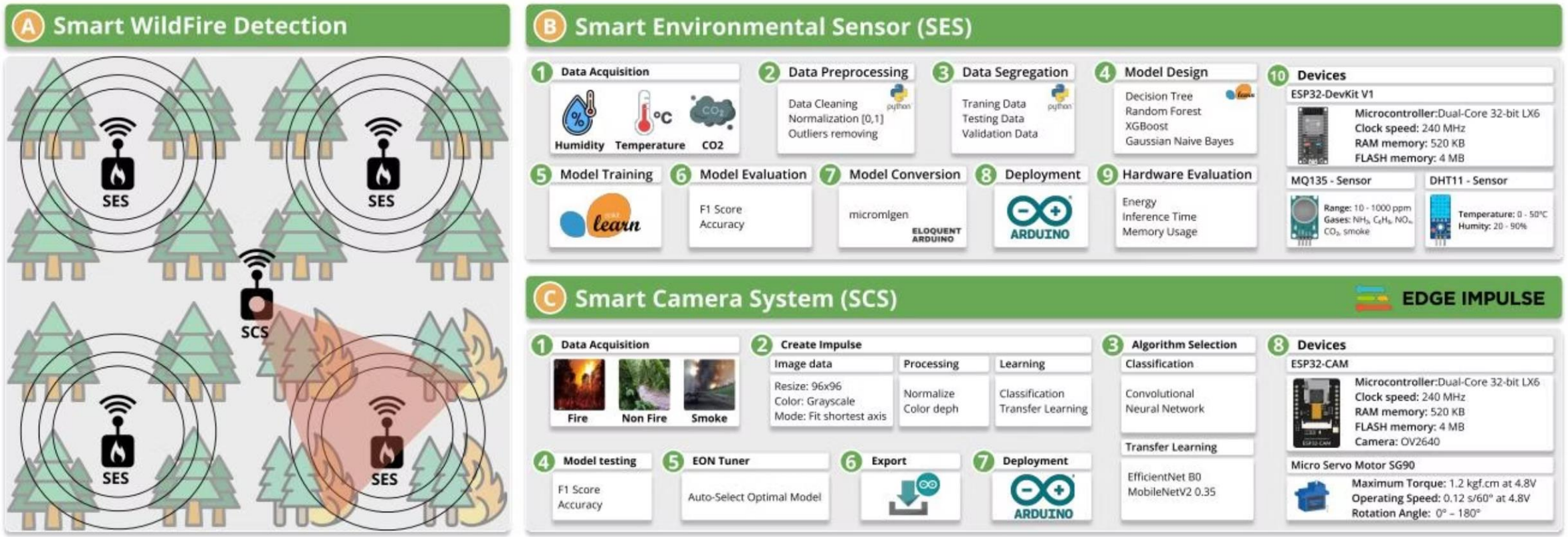
Scalability

Limited scalability and difficulty in covering remote areas.

Reliability

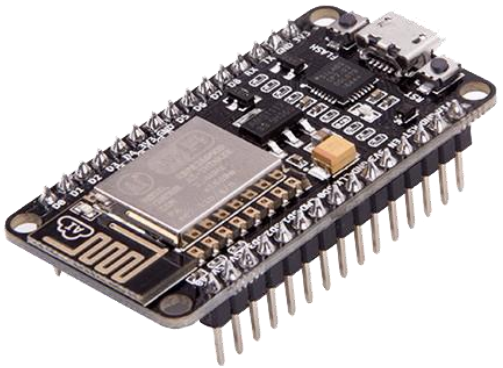
Extensive calibration needs can lead to inaccuracy, and cameras suffer obstruction.

The Smart Wildfire Detection Workflow



Smart Environmental Sensor (SES) Performance Metrics

Algorithm	Energy	Latency	RAM	Flash	Accuracy
Decision Tree	451.62 mW	1 µs	19.6 KB	288.3 KB	test = 89.43%
Random Forest	451.62 mW	1 µs	19.6 KB	288.3 KB	test = 89.33%
XGBoost	403.65 mW	57 µs	19.6 KB	358.8 KB	**test = 94.27%**
GNB	402.43 mW	9 µs	19.6 KB	289.3 KB	test = 79.53%



MEM

Efficient memory usage of 4% (RAM) and 9% (Flash).

Latency Analysis

Sub-milliseconds delay.

Smart Camera System (SCS) Performance Metrics

Model	Latency	RAM	Flash	F1	Accuracy
EfficientNetB0	12 s	1.3 MB	4.5 MB	0.93	93.4%
MobiliNetV2 0.35	1.6 s	334.6 KB	334.6 KB	0.92	92%
Custom CNN	**813 ms**	**182.8 KB**	**89.5 KB**	0.92	91.5%

Quantization summary (float32 → int8)

83%
Latency 62-84% lower

75%
Lower RAM usage 50-75%

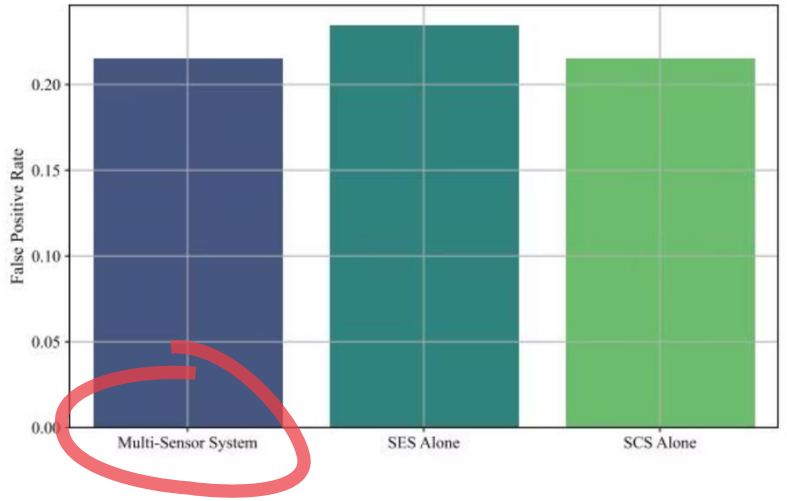
71%
Lower Flash footprint 63-71%

>1%
Overall accuracy degradation

Simulation Results and Conclusions

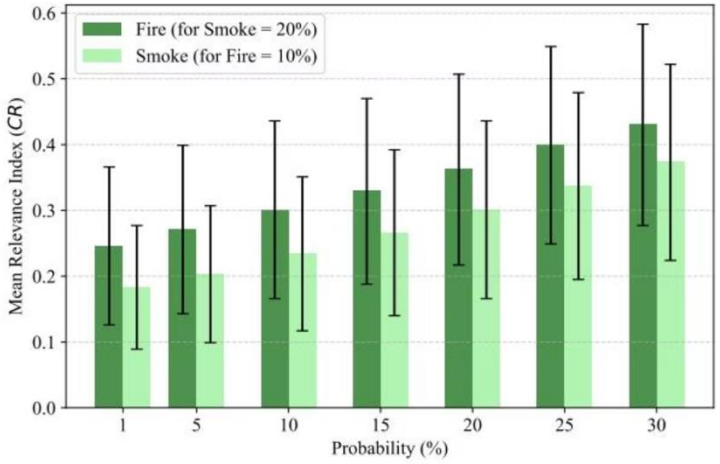
The multi-sensor system, which combines SES (10 devices) and SCS (1 device), achieved a 97.03% agreement rate and significantly and significantly reduced false positives, demonstrating its reliability in fire detection.

False Positive Rate Comparison



The multi-sensor system achieved a reduction in false positives positives compared to the individual modules, highlighting the the advantage of sensor fusion in mitigating false alarms, thereby thereby increasing detection reliability.

Contextual Relevance Index



The multi-sensor system maintains a higher relevance index index across different probability levels, with lower variation and variation and greater stability in measurements.

Thank you

-- Innovative solutions can ignite progress in future cities.

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