ABSTRAK

Laju pernapasan merupakan parameter vital indikator awal perburukan klinis pasien, namun pengukuran manual rawan kesalahan subjektif dan metode kontak berisiko menularkan patogen serta menimbulkan ketidaknyamanan fisik. Penelitian ini merancang alat deteksi laju pernapasan *non-contact*, portabel dan ekonomis menggunakan sensor kamera termal AMG8833 yang diintegrasikan dengan sensor ultrasonik HC-SR04 pada mikrokontroler ESP32-S3. Sistem menerapkan mekanisme validasi ganda otomatis sebelum pengukuran dimulai, yaitu memverifikasi jarak wajah melalui sensor HC-SR04 dan mengonfirmasi keberadaan wajah manusia berdasarkan rentang temperatur 32°C–40°C dari sensor AMG8833. Data temperatur pada *Region of Interest* (RoI) dihaluskan oleh *Moving Average Filter* (*window* = 7 poin) untuk meredam *noise*, kemudian diproses menggunakan algoritma *Peak Detection* adaptif yang melacak perubahan temperatur relatif ($\Delta T \geq 0,35$°C) dengan jeda waktu satu detik untuk mencegah kesalahan hitung ganda. Nilai *Breaths Per Minute* (BPM) dikalkulasi dari rata-rata interval antar-puncak selama 30 detik dan ditampilkan melalui layar TFT LCD. Hasil pengujian menunjukkan sensor HC-SR04 memiliki rata-rata *error* 2,1%, sedangkan sensor AMG8833 memiliki *error* temperatur 4,97% terhadap instrumen acuan standar laboratorium Fluke 59 MAX. *Moving Average Filter* terbukti efektif menurunkan standar deviasi *noise* sebesar 6,0%. Pengujian akurasi terhadap 30 responden menghasilkan rata-rata *error* 2,4% pada mode tanpa masker dan 2,33% pada mode menggunakan masker, sehingga akurasi sistem mencapai di atas 97% pada kedua kondisi. Pengujian *user experience* memperoleh skor kelayakan 79,2%, membuktikan alat ini akurat, praktis, dan mudah dioperasikan bagi pengguna awam.

Kata Kunci: Laju Pernapasan, AMG8833, HC-SR04, ESP32*, Peak Detection*, *Moving Average Filter*, *Non-Contact.*

ABSTRACT

Respiratory rate is a vital early indicator of patient clinical deterioration. However, manual measurement is prone to subjective error, and contact-based methods carry pathogen transmission risks alongside physical discomfort. This study developed a portable, economical, non-contact respiratory rate detection device integrating an AMG8833 thermal camera sensor and an HC-SR04 ultrasonic sensor on an ESP32-S3 microcontroller. The system employs an automatic dual-validation mechanism before measurement begins, verifying the patient's facial distance via the HC-SR04 sensor and confirming the presence of a human face based on the AMG8833 thermal temperature range of 32°C–40°C. Temperature data within the Region of Interest (RoI) is smoothed by a Moving Average Filter (window = 7 points) to reduce noise, then processed using an adaptive Peak Detection algorithm tracking relative temperature changes ($\Delta T \geq 0.35°C$) with a one-second cooldown interval to prevent double-counting errors. The final Breaths Per Minute (BPM) value is calculated from average inter-peak intervals over a 30-second duration and displayed on a TFT LCD screen. Test results indicate an average error of 2.1% for the HC-SR04 sensor and a 4.97% temperature error for the AMG8833 sensor against the Fluke 59 MAX laboratory reference standard. The Moving Average Filter effectively reduced noise standard deviation by 6.0%. Accuracy testing on 30 respondents yielded average errors of 2.4% (unmasked mode) and 2.33% (masked mode), achieving overall system accuracy above 97% under both conditions. User experience testing achieved a 79.2% feasibility score, confirming that the device is accurate, practical, and user-friendly for lay users.

Keywords: Respiratory Rate, AMG8833, HC-SR04, ESP32, Peak Detection, Moving Average Filter, Non-Contact.