Infrared Thermal Imaging for Embedded Child Presence Detection System: Feasibility and Performance Evaluation

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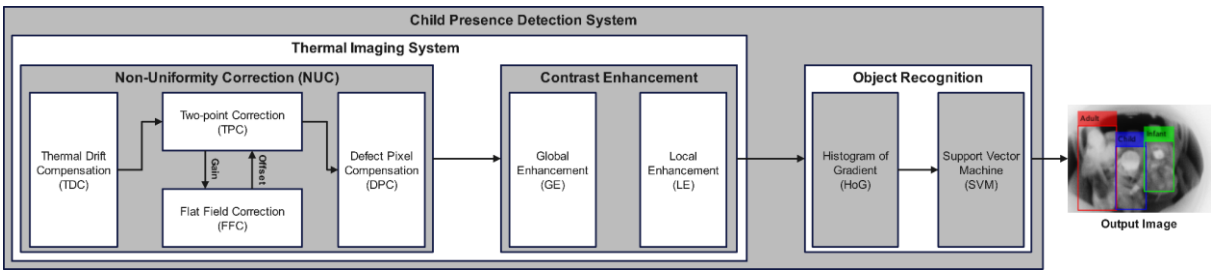
Motivation

- Various regulations and standards have been updated with the perspective that systems using in-cabin sensors should be robust enough to respond to a range of internal and external situations, such as when the vehicle temperature rises significantly in a dark, enclosed underground parking lot.
  - European New Car Assessment Program (Euro NCAP)
  - Hot Car Act (USA)
- Thermal imaging offers the advantage of easily determining whether the in-cabin temperature could reach levels that might have fatal effects (such as heatstroke or death) on occupants (e.g., infants, adults) inside the vehicle

(a) Non-emergency case

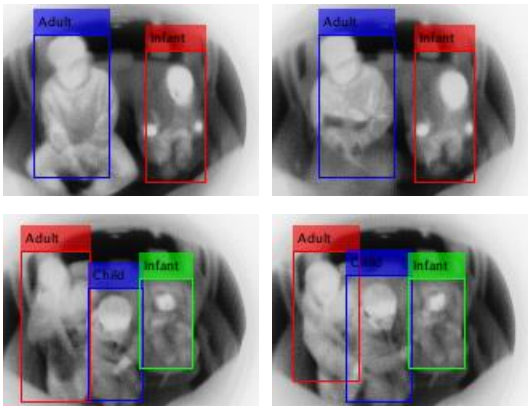
(b) Emergency case

Thermal Imaging-based Child Presence Detection System



- **Non-Uniformity Correction (NUC)** [1]
  - **TDC**: Compensates for temperature changes caused by using an uncooled detector.
  - **TPC**: Compensates for non-uniformity caused by using ROIC (Read-Out Integrated Circuit) detector.
  - **FFC**: Updates the offset coefficient required for the TPC.
  - **DPC**: Compensates for defective pixel values caused by detector issues.
- **Contrast Enhancement (CE)** [2]
  - **GE**: Applies algorithms such as AGC (Automatic Gain Control).
  - **LE**: Enhances contrast to enable visual identification of detailed objects while preserving edges.
- **Object Recognition (OR)**
  - **HoG**: Computes the Histogram of Gradient feature vector.
  - **SVM**: Performs object recognition operations based on the computed Histogram of Gradient feature vector.

Experimental Results



Camera Type	Label	Precision	Recall
Thermal Camera (Ours)	Adult	0.95	0.96
	Child	0.89	0.92
	Infant	0.85	0.88
Visible Camera	Adult	0.42	0.46
	Child	0.39	0.41
	Infant	0.34	0.35

References

[1] C.-H. Choi, J. Han, J. Cha, H. Choi, J. Shin, T. Kim, and H. W. Oh, "Contrast Enhancement Method Using Region-Based Dynamic Clipping Technique for LWIR-Based Thermal Camera of Night Vision Systems, " *Sensors*, vol. 24, no. 12, p. 3829, 2024.

[2] H. W. Oh, C.-H. Choi, J. Cha, H. Choi, J. Han, and J. Shin, "An SoC FPGA-Based Integrated Real-Time Image Processor for Uncooled Infrared Focal Plane Array," in Proc. *Euromicro Conference on Digital System Design (DSD)*, 2023, pp. 660-668.