MRV-21
Product Specifications

PROCESS	Product Definition
SUPPLIER	Movon Corp.
DATE	01. August. 2022

1. REVISION HISTORY

Revision No.	Revision date	Revision history
Version 0.0	04. Dec. 2020	Initial release
Version 1.0	14. Apr. 2021	Engineering sample(ES) spec. update
Version 2.0	24. Nov. 2021	Accuracy specification update
Version 2.1	01. August. 2022	Functional Specification

2. INTRODUCTION

2.1 Purpose

This document describes the features, specifications and major components for the MRV-21, which is a reconfigurable fusion ADAS that incorporates a 77GHz RADAR sensor and a HD camera sensor modules.

3. GENERAL FEATURES

3.1. Product Specification

[Vision Part]

Item	Description	Remark
OS	Embedded Linux	-
Processor	Cortex-A7 Quad Core	-
Memory	512MB DDR3 / 512MB NAND	-
SD Card	Up to 128GB, Over Class10 (SDHC), MLC	-
Camera	IMX323 (SONY FHD Sensor) Diagonal : 60° / Horizontal : 52°	Front Camera
Video Record	H.264 (HD 30fps)	Format-free Supported
Inner Mic	Built-in Mic	For Voice Record
Speaker	Built-in Speaker (Max 1W, 8Ohm)	For Voice Guidance
Key	Push Button Switch	-
LED	Status LED 1EA (RGB Color)	-
G Sensor	3-axial Acceleration Sensor	-
GNSS	2.5Φ 4P Phone Jack G-Mouse (GPS, GLONAS)	Option

[Radar Part]

Item		Description	Remark
RF Front-end		3Tx / 4Rx	Maximum 3Tx
Frequency		76 ~ 77GHz	output power : 12 dBm
Range	Min. ~ Max.	0.7m ~ 160m[1]	-
	Resolution	0.7m	-
	Accuracy	≤0.35m[2]	-
Velocity	Min./Max.	-200~200km/h	-
	Resolution	1.1km/h (0.3m/s)	-
	Accuracy	≤0.52km/h(0.15m/s) [2]	-
Angle	Azimuth Field of View	± 12°	3dB beamwidth
	Elevation Field of View	± 4°	3dB beamwidth
	Azimuth angle resolution	15°	-
	Azimuth angle accuracy	≤0.1°[2]	-
Update Cycle Time		66ms	15 fps
Tracking Target		Maximum 20	-

[1]Outdoor measurement. This data is measured with MRV-21 placed outdoor and a stationary vehicle at 160meter ahead.
[2] Measured at bore sight, for a target showing SNR > 25dB

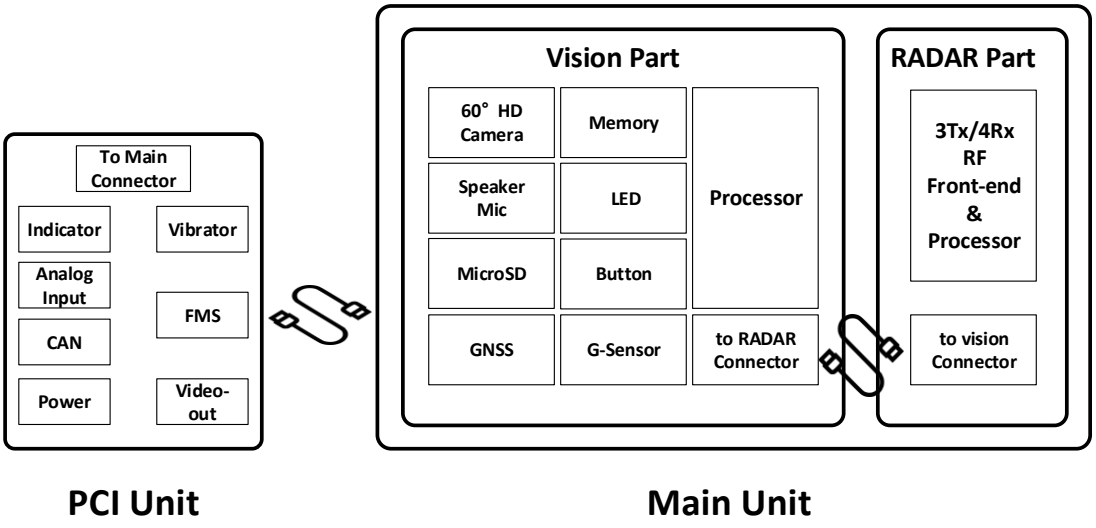
[PCI Unit]

Item	Description	Remark
Video Out	CVBS 1Vp-p 75Ω NTSC	-
Analog Signal Input	Vehicle Analog Speed	H:3.3~50V/L:0~2V
	Vehicle Left/Right Turn Speed	
Accessory Port	CAN Reader	CAN 2.0A/B Input
	Indicator (MIND-20 & MIND-30)	RS-232C
	FMS	RS-232C & ACC out
	Vibrator	-
Power Input	DC 12/24V IGN or ACC	DC 9~36V

[Common Factor]

Item	Description	Remark
Performance Temperature	-10~60°C	-
Operating Temperature	-20~70°C	-
Storage Temperature	-30~85°C	-
Power Consumption	Max. 1A @ 12V Max. 600mA @ 24V	-
Dimension	64mm x 155mm x 25.2mm	Main Unit
Weight	240g	Main Unit without cable

3.2.Hardware Block Diagram

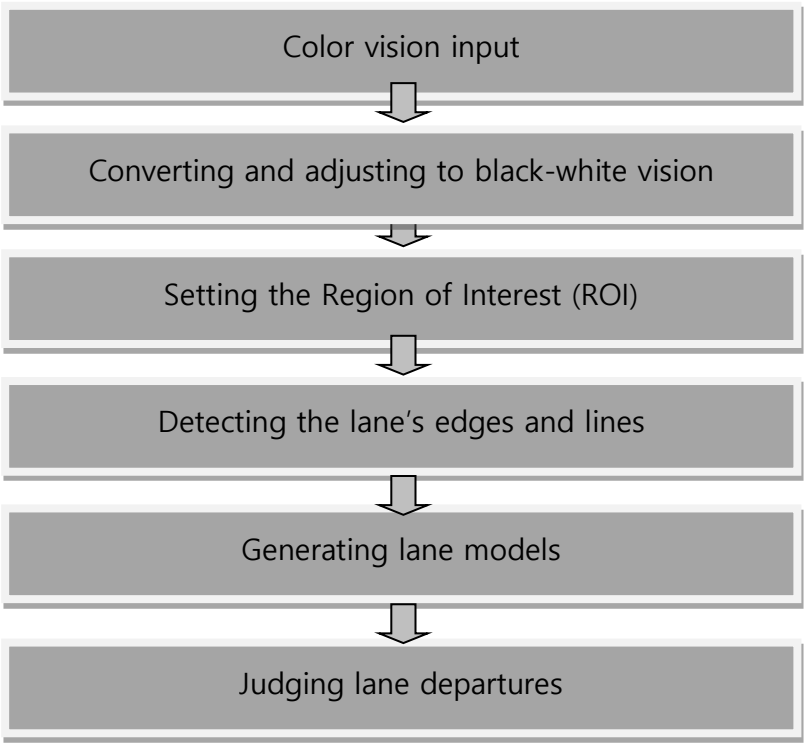


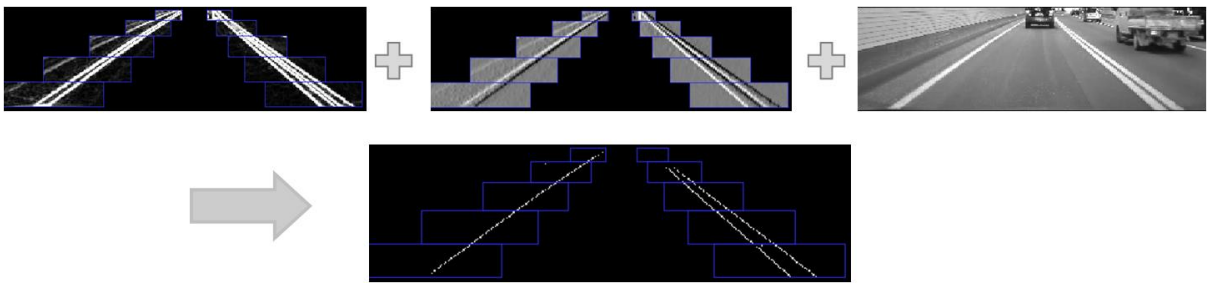
4. FUCTIONAL SPECIPICATION

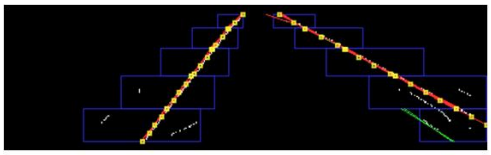
4.1 Lane Departure Warning System (LDWS)

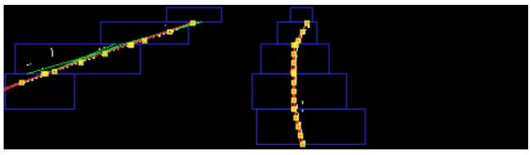
MRV-21 prevents a possibility of getting into a car accident with a single camera vision based system that recognizes lane departure while drowsy or careless driving.
The principle of MRV-21 is to detect the lane markings around the vehicle and to alert when the vehicle departs the lanes by analyzing distances of the left-to-right lanes to the vehicle's front tires through the camera.

The below flow chart shows the algorism of MRV-21 .





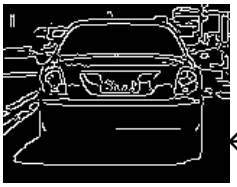




	Item	Description
1	Lane Detection Success	After the recognition of lane markings, the green line is appeared.
2	LDW 1	The red line is appeared with warning sound generated.
3	LDW 2	The red line is appeared without warning sound generated because blinkers are turned on.

4.2 Forward Collision Warning System (FCWS)

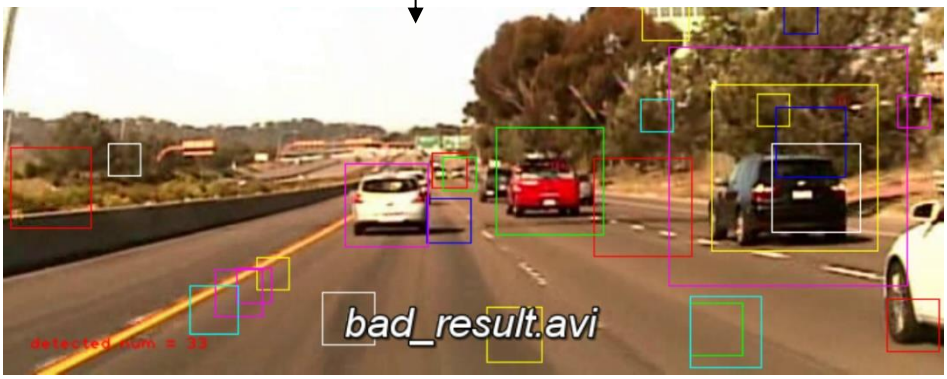
Search candidate area whose possibility of the car existence is high from the input image



← Canny Edge Abstract

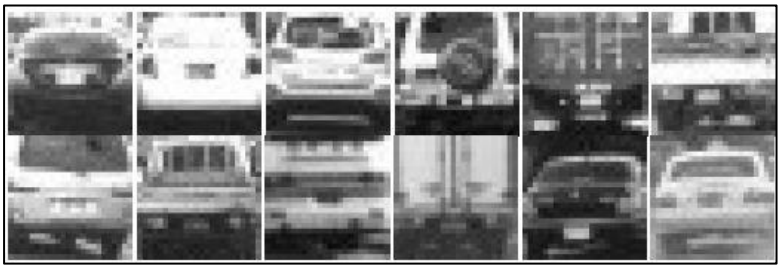
← Hog Edge Abstract

From candidate area lists, check whether the car exists or not



If the car is detected, we make the candidate car lists

From candidate car lists, verify car existence by using real-time machine learning algorithm



Compute the distance for the detected car

$$pos = \left(1.0 - \left(\frac{\text{LeftLower.y} - \text{HorizontalLineY}}{\text{CameraHeight} - \text{HorizontalLineY}}\right)\right) \times 100$$

LeftLower.y: 검출된 차량의 좌측 하단 y 좌표
HorizontalLineY: 수평선(소실선)의 y 좌표
CameraHeight: 입력 영상의 세로 길이
pos: 검출된 차량이 노면에 닿는 접선과의 거리

Vehicle Tracking

Compute Time-To-Collision (TTC) to warn or alert car collision

TTC (Time-to-Collision) Warning
Assists the driver to keep the safe distance from the front vehicle with audio and visual warnings. (Active from 18mph, 30km/h)
(i.e) If Current vehicle speed is 20m/s(72km/h) and TTC-set value is 0.6 second, when there is a front car within 12meter ahead, TTC warning is generated using the below calculation method.

- $s = v \times t = 20 \times 0.6 = 12m$

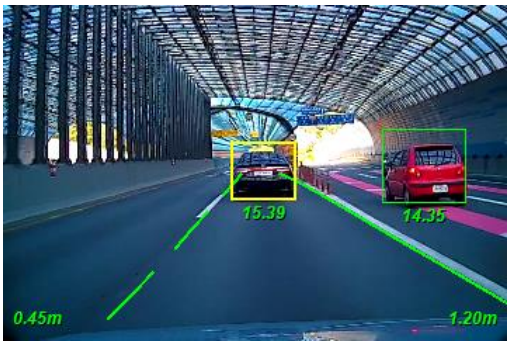
Forward Collision Warning (FCW)
warns the driver of an impending crash with audio and visual warnings.
(i.e) If the front car's vehicle speed is 10m/s(36km/h) and the acceleration value is $0m/s^2$, my car's vehicle speed is 20m/s(72km/h) and its acceleration value $6m/s^2$ at the same time TTC-set value is 0.6 second, when there is a front car within 7.08 meter ahead, FCW waring is generated using the below calculation method.

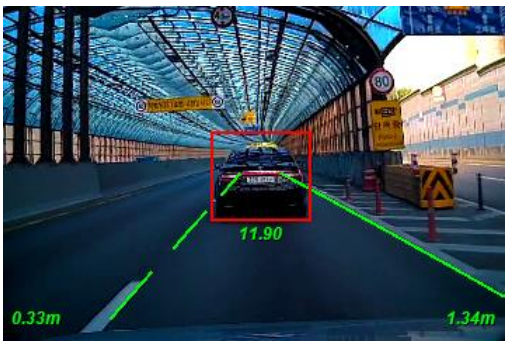
- $S = v * t + 0.5 \times a * t^2 = 10 \times 0.6 + 0.5 \times 6 \times 0.6^2 = 7.08m$

Forward Proximity Warning (FPW)
Notifies the drive when there is a vehicle existing in the detection range and the driver's car moves forward. Detection range can be setup as 1.2m / 2.0m / 3.0m (Active from 0 ~ 18 mph or 30km/h)

Front Vehicle Start Alarm (FVSA)

Notifies the driver if the front vehicle starts to move forward from 0 speed (complete stopped status) and the driver's car is not moving within 2 seconds.





4.3 Pedestrian Warning Systems (PCW)

Detect pedestrians by template matching

↓

Classify ground, tall vertical structure.

Pedestrians are footed on the ground • Pedestrians are between 1 to 2 meters above the ground (height) • Pedestrians are less than 1

↓

Reject detections without sufficient candidate pixels

↓

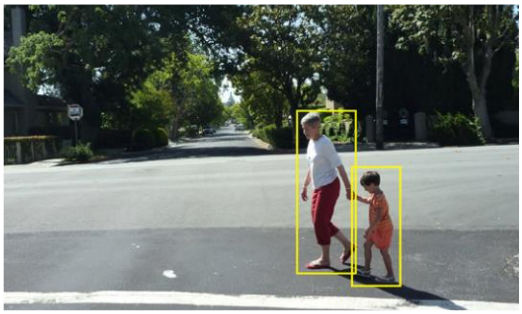
Classify pedestrians using shape & appearance features

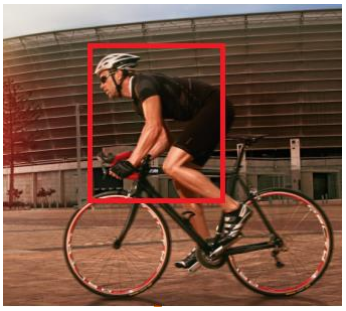
↓

Track pedestrians using ego-motion estimates

↓

Judging Pedestrian Warning Time





4.4 RADAR-Vision Fusion Technology

4.4.1 Camera & Radar fusion algorithm

: A mono-camera-based ADAS doesn't have stable performance in poor lighting and environmental conditions, and conventional RADAR only-based ADAS has object classification issue. MRV-21 is using Camera & Radar fusion algorithm. It combines the benefits of both sensors in the most effective way possible. It tracks the vehicle in front with radar and camera sensor together, which reduces false alerts from single sensor and increases the measurement reliability, range and accuracy. Also, the radar supports more accurate performance during the severe weather conditions such as foggy, heavy rain, night, direct sunlight and so on.

Heterogeneous sensor data is set to be precisely synchronized in time and rate systematically. The patented computer vision perception algorithm intermingled together with a signal processing algorithm for the 77GHz RADAR process and analyze the data. As a result, MRV-21 first detects, identifies, and tracks objects and provides distance, speed and location information of vehicles, pedestrians, lane marks, and others. The entire sequences from raw data collection to post-processing are completed at the rate of 15Hz.

The vision sensor analyzes the video data to determine the ROI, detect lanes and identify the vehicle ahead. Meanwhile, the radar signal is processed to detect objects, range and relative velocity. The detection information from two sensors are fed to our optimized matching algorithm. With a successful matching, more accurate distance, velocity and acceleration is assigned to the target vehicle. We track and filter the information adaptively for more reliable fusion results. Based on these information, TTC and possible collision situation is estimated and collision avoidance warnings are generated

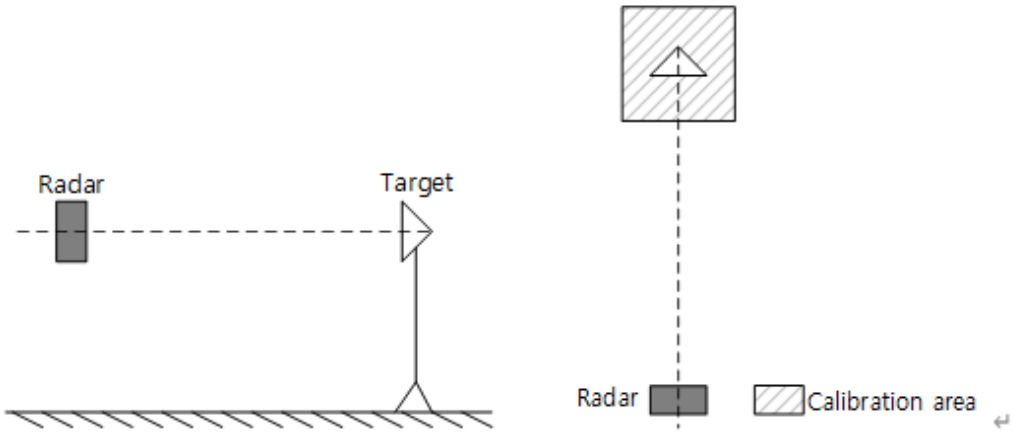
4.4.2 77G Radar technology

: MRV-21 is using high performance premium mid-range radar sensor (160m) developed in-house. It provides the best radar performance in a state-of-the-art sensor technology. One of the features of the new radar generation is a higher resolution compared to the previous radar generations, with which a more exact picture of the traffic situation can be gained. In addition, road limits such as curbstones as well as the height of objects like the tails of a traffic jam under a bridge are detected thanks to the sensors' elevation measurement accuracy. It shows excellent performance to detect and track motorcycles.

Horizontal FOV is ±6° @160m, ±20° @50m and Vertical FOV is ±5°. Range Accuracy is <±0.5m. Frequency band is 76-77 GHz.

4.4.3 Radar Calibration

The radar sensor should be properly mounted to meet the pitch and roll angle requirements. The sensor performs self-calibration for yaw angle with a target placed inside the calibration area.


Radar
Target
Radar
Calibration area