Thermal cameras assessment for pedestrian protection

An empirical and simulation perspective

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AutoSens

Joint Research Centre

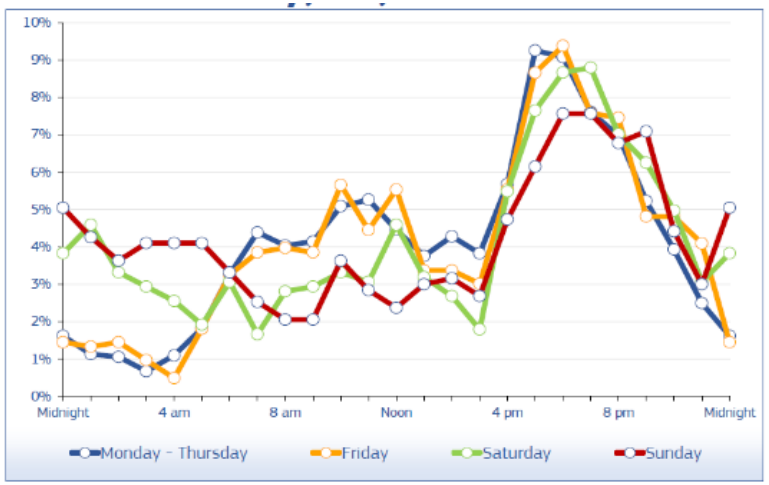
Context of this work

Pedestrians fatalities happens in low visibility conditions…

…when current AEB systems are ineffective

*Pedestrians fatalities on **Advanced light &/or Advanced weather** conditions:*

***80%** in the US*
***70%** in Europe*



Source: CARE database, data available in May 2017

*More than **50%** of all pedestrian fatalities occured between **4pm and midnight** in the EU*

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New Cars' Pedestrian-Safety Features Fail in Deadliest Situations, Study Finds

AAA finds pedestrian detection ineffective at night, when most deaths occur

Source: NHTSA 2015-2019, ERSO 2017

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EU objectives and US rulemaking proposition

NHTSA published rulemaking proposal to integrate Automatic Emergency Braking and Pedestrian AEB working at night and higher speed

EU Vision Zero ambitions to reduce by half the number of fatalities by 2030 and approach Zero by 2050

Thermal Vision solves the nighttime issues

Visible Camera

Active imagery with sun and headlamp

Thermal Camera

Passive imagery unsensitive to lighting conditions

JRC Introduction

European Commission

Science for policy

ANTICIPATE

INTEGRATE

IMPACT

JRC purpose

The Joint Research Centre provides **independent**, **evidence-based knowledge** and science, **supporting EU policies** to positively impact society.

JRC role

- **Independent** of private, commercial or national interests
- Works for more than **40 European Commission's policy departments**

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JRC sites

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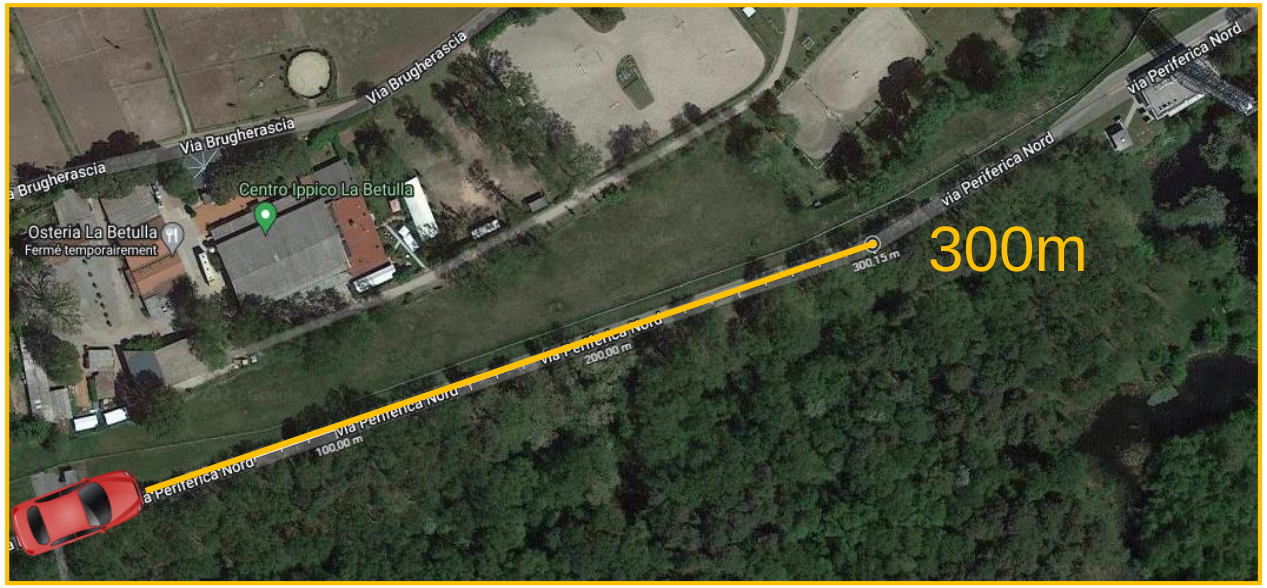
European Commission JRC lab test at Ispra, Italy

- The Joint Research Centre (JRC) in Ispra : 3rd largest EC site.
- Ideal infrastructure: Real life test of pedestrian detection



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JRC Testing campaign

Set-up & Data collected

Tesla HW 3.0

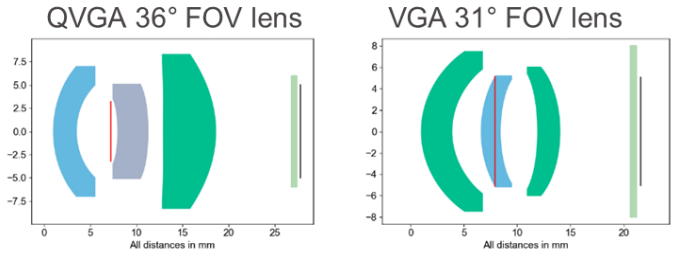
ADAS 3 camera setup

35, 50 and 120 FoV

1.2Mp – 3.7µm pixels

VS

Thermal camera images



QVGA Thermal camera

36° FoV

0.077 Mp – 12µm pixels

VGA Thermal camera

31° FoV

0.3Mp – 12µm pixels

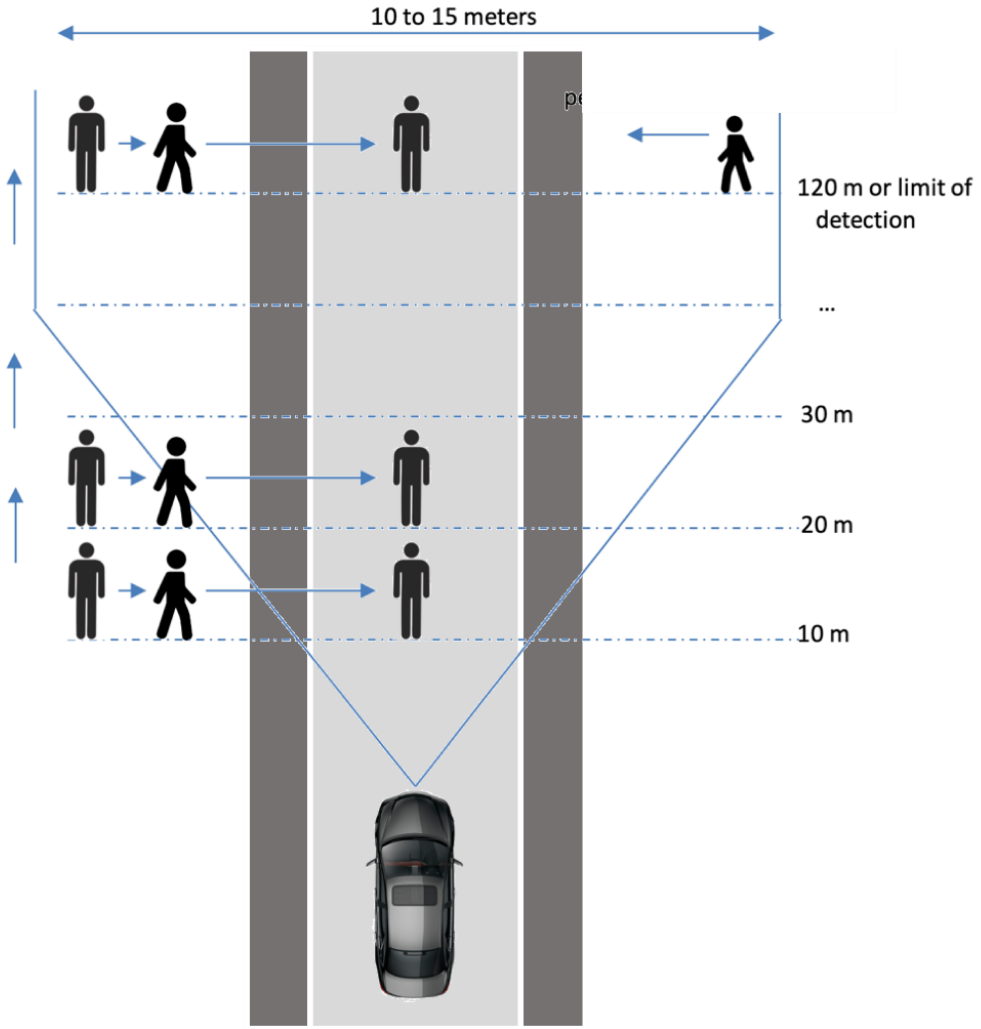
Set-up & Data collected

207 scenarios

Pedestrian crossing from the right scenario

from 6 to 18°C

between 38 and 93%



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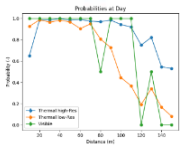
Scientific exploitation

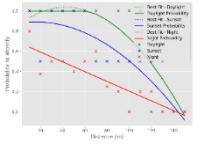
1. Data collection

2. Data Inference

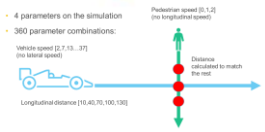
3. Confidence score



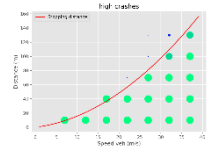
4. Vision Model and probability of detection



5. Definition of braking rules



6. Results of simulation



Data exploitation

Simulation Experiment

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Data exploitation

Processing

Thermal Image

Inferred thermal image

Inference with Resnet50 Neural Network

Fine tuned with 5000 thermal images

Confidence level > 60%

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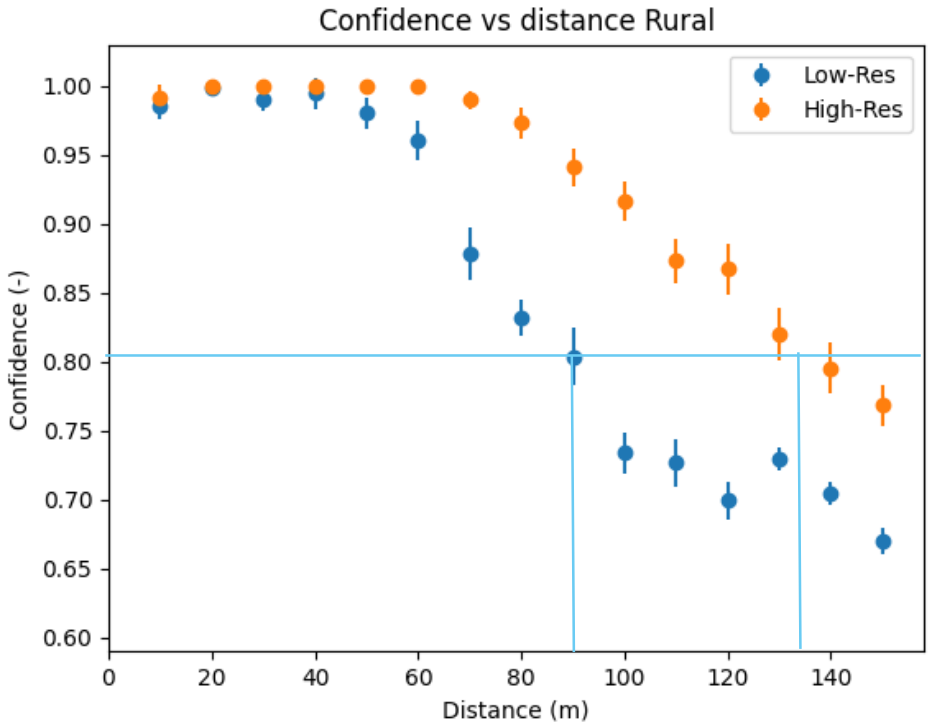
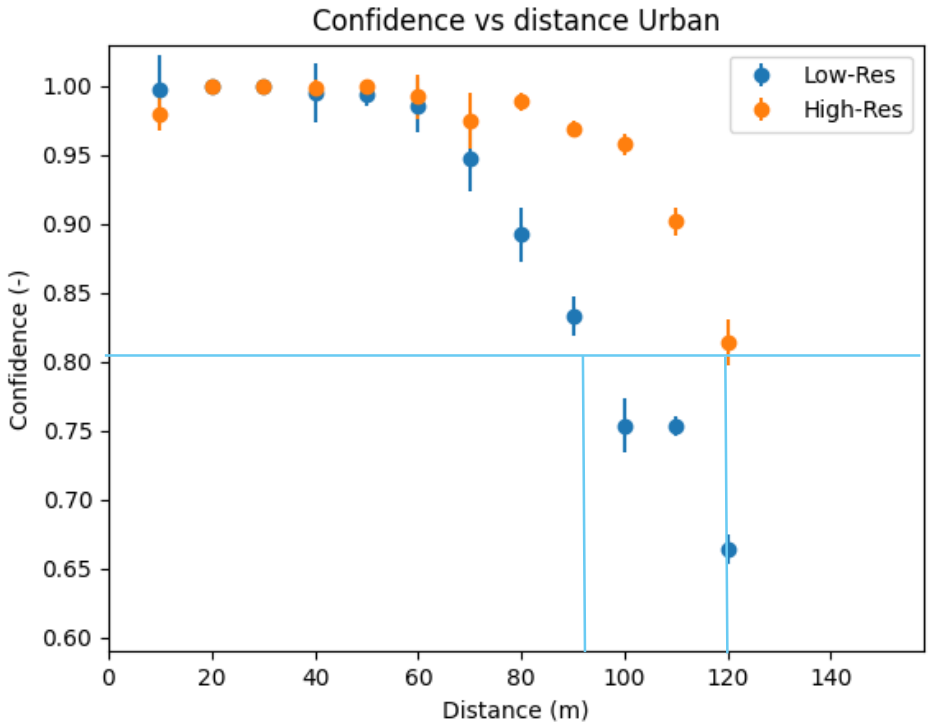
Confidence Score:
Pedestrian detection vs distance for thermal cameras





Pedestrian detection range :
> 90m for QVGA resolution sensor
> 120m for VGA resolution sensor

No significant impact of rural and urban environments

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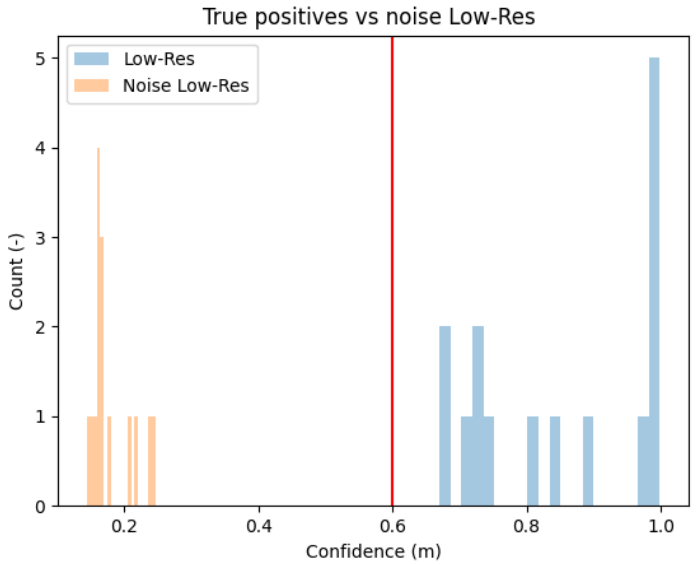
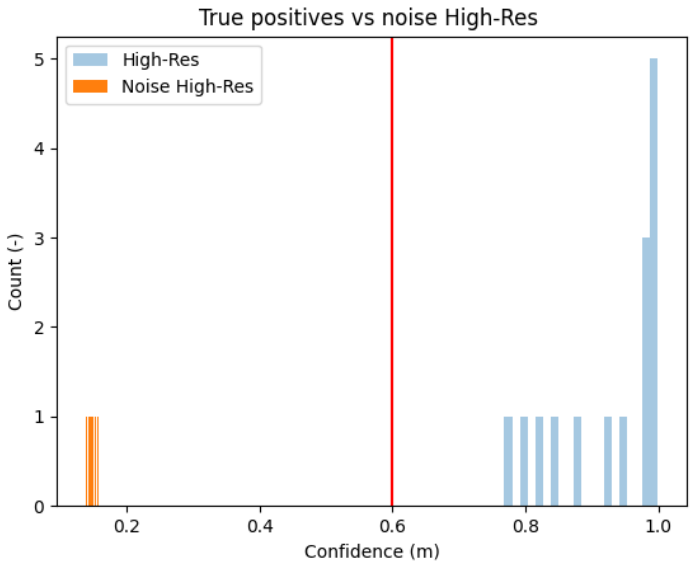
Capability of rejecting false positives

QVGA resolution



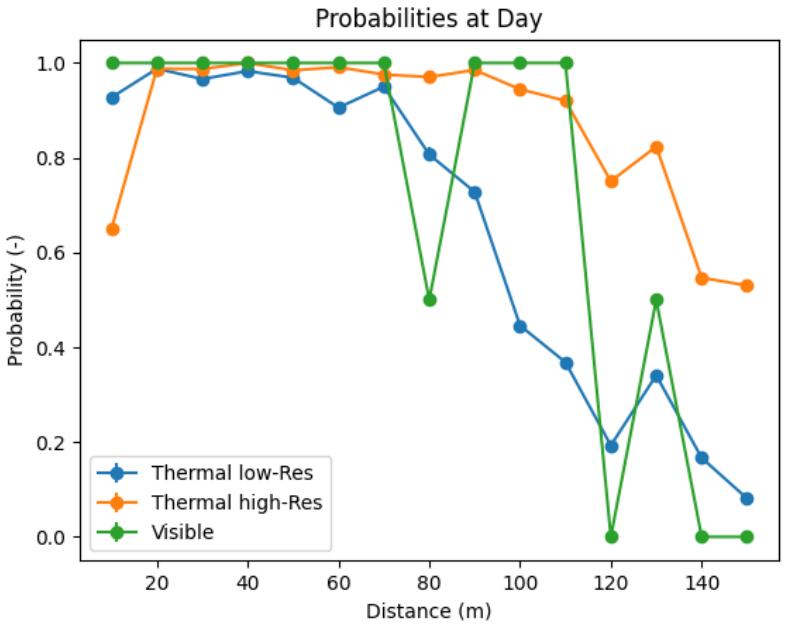
VGA resolution

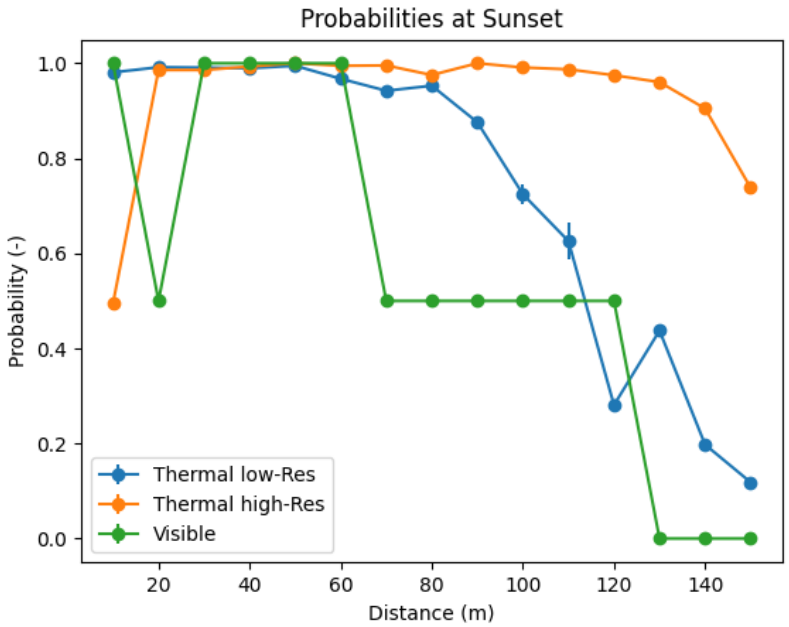


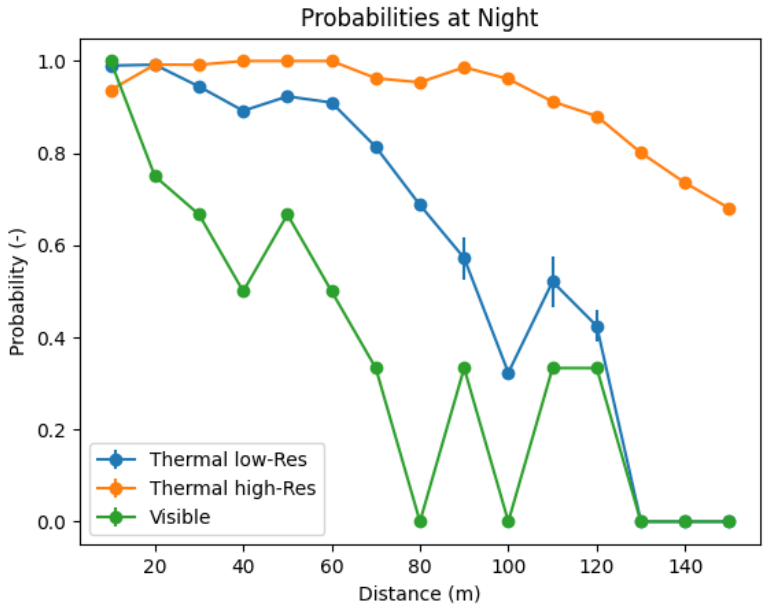
High capability to differentiate true positive from false positive

With higher resolution, the gap between true positive and noise is even larger

Pedestrian detection vs lighting conditions for thermal and visible cameras







Detection confidence is identical whatever the lighting condition for thermal cameras

Detection confidence drops dramatically when lighting conditions are degraded for visible camera

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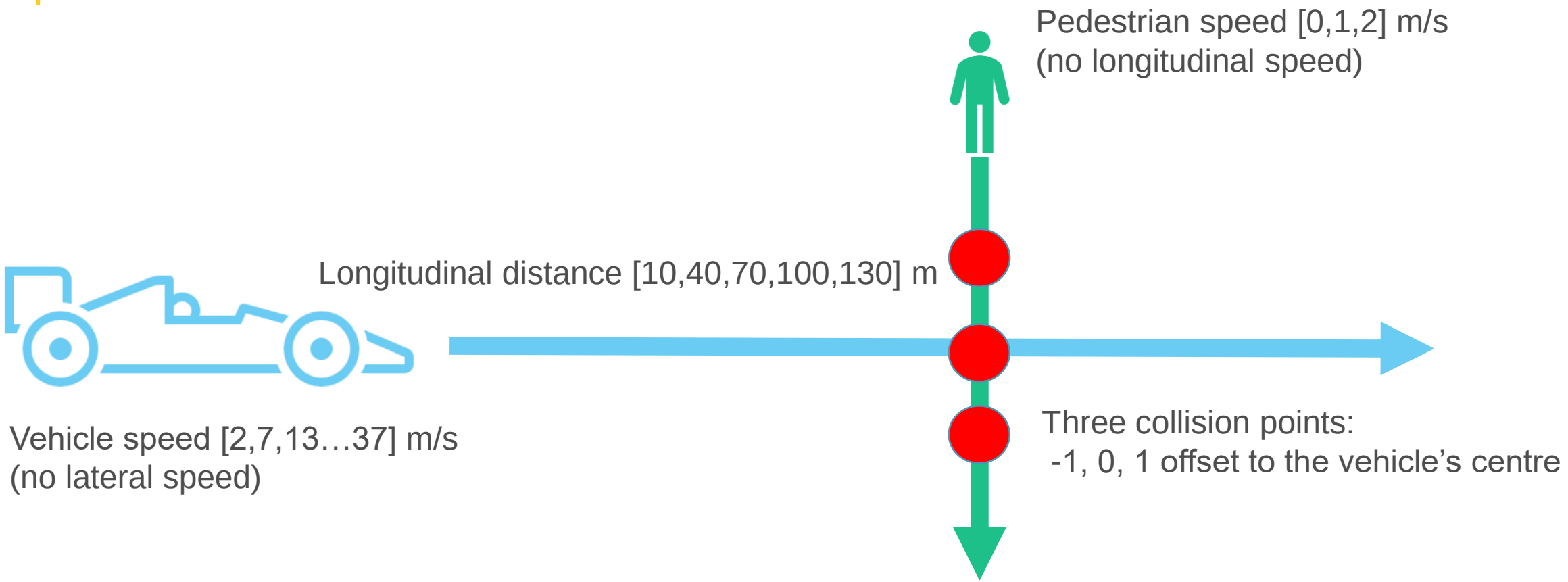
Simulation experiments

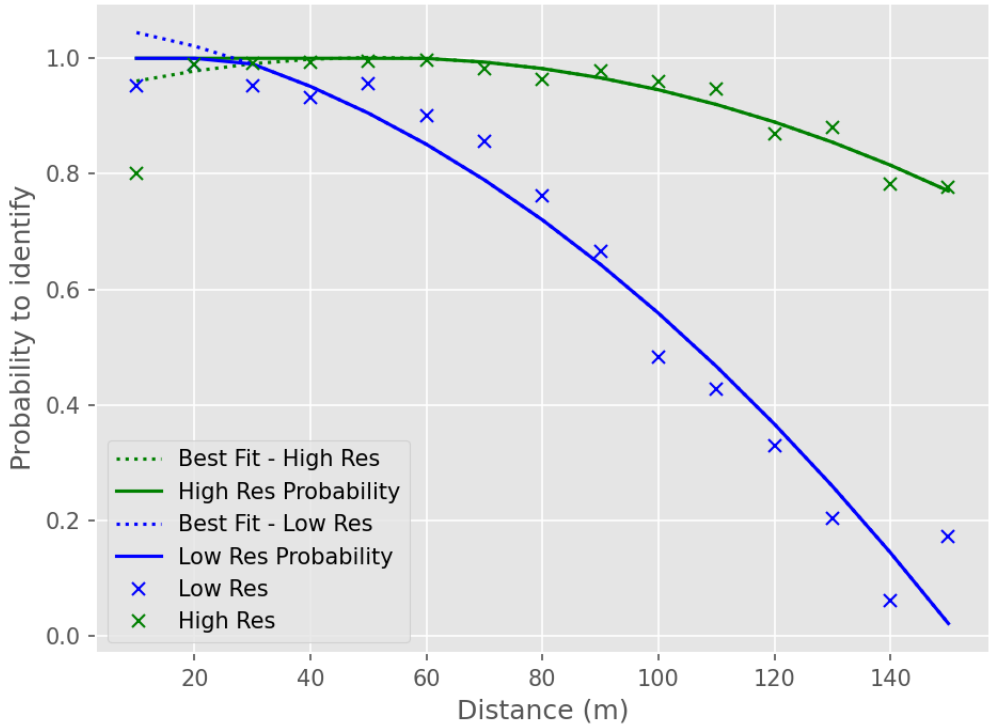
Simulation framework and Parameters



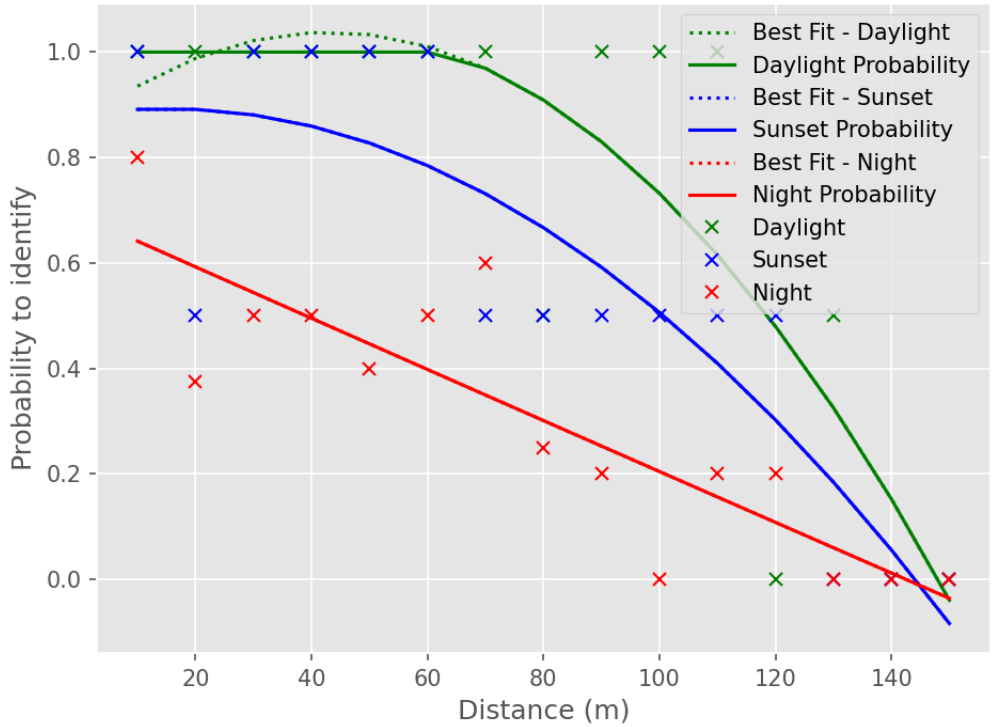
- *Simulations are based on the Fuzzy Safety Model, considering the "cut-in" vehicle being the pedestrian*
- *Deceleration, reaction time and jerk values are as in UN Reg 157*

Introducing the vision level

Thermal camera



Visible camera (day, sunset, night)



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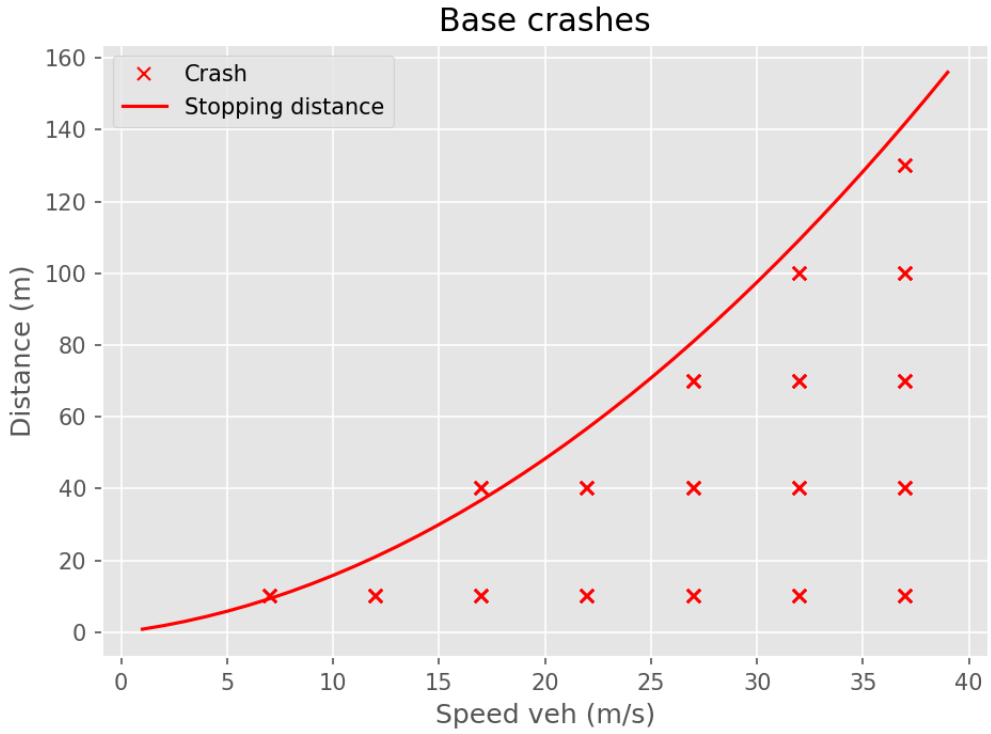
Simulation results

Base scenario results

The base model sees everything :

- In some cases, there is not enough time to react.
- Moreover, in some cases, the distance is smaller than the stopping distance, so there is a crash



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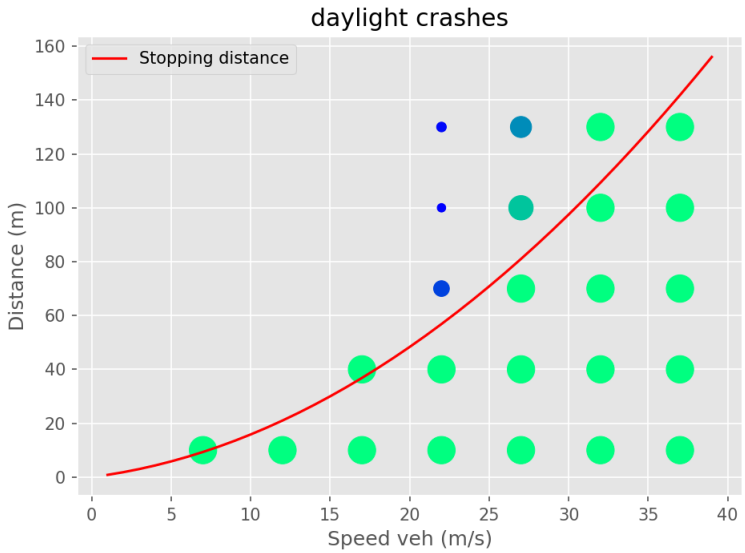
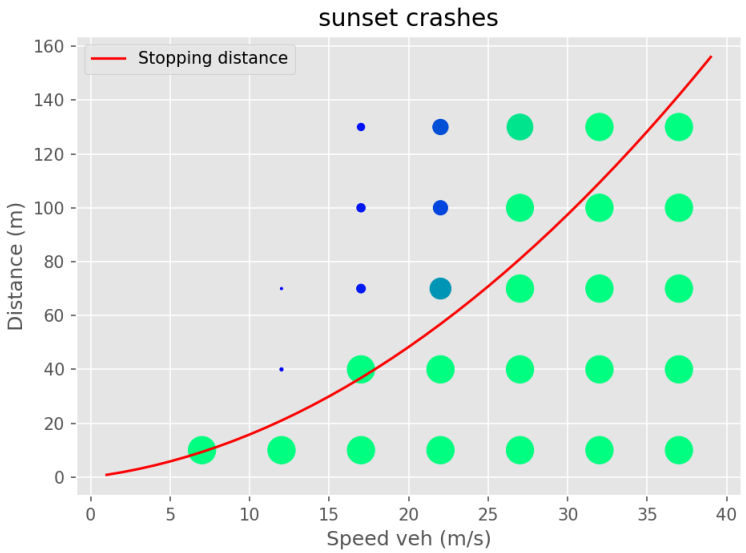
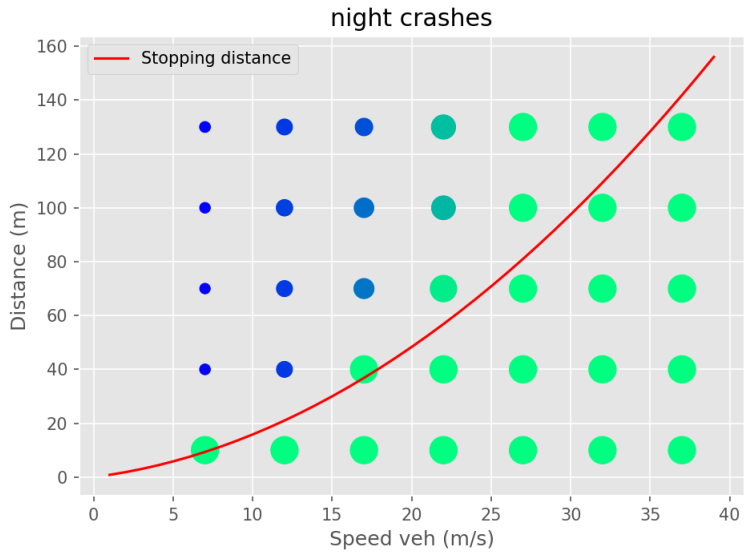
Crashes simulations for Visible camera



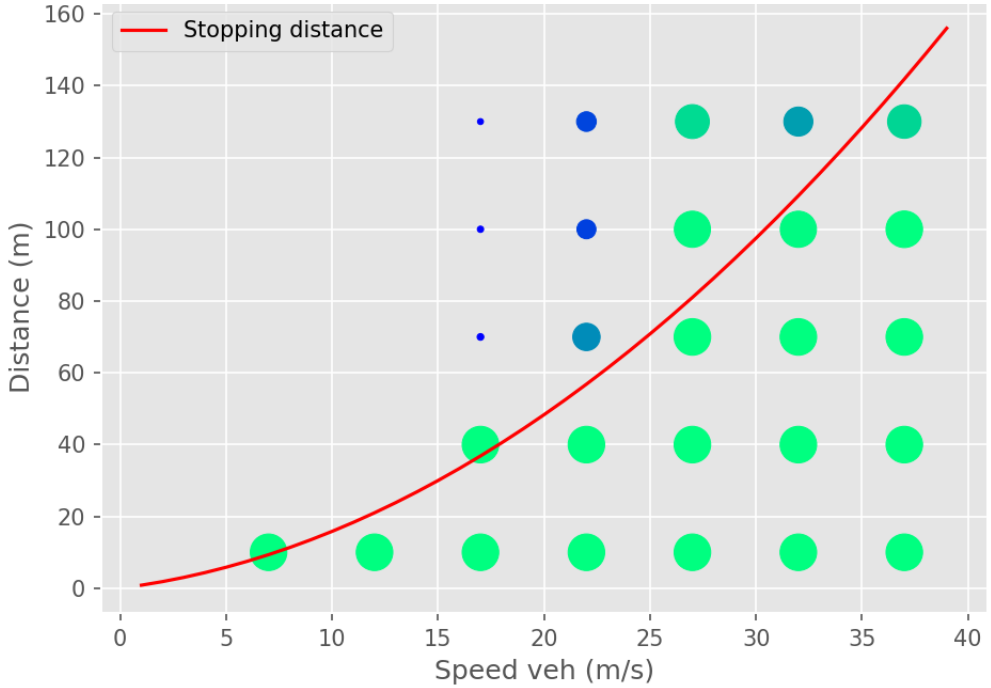




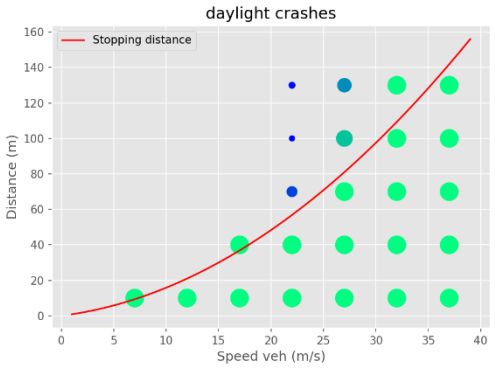
- In daylight, crashes occur from 20m/s ie 72km/h
- During sunset, crashes occur from <15m/s ie <54km/h
- In night conditions, crashes occur from 5 m/s ie <20km/h

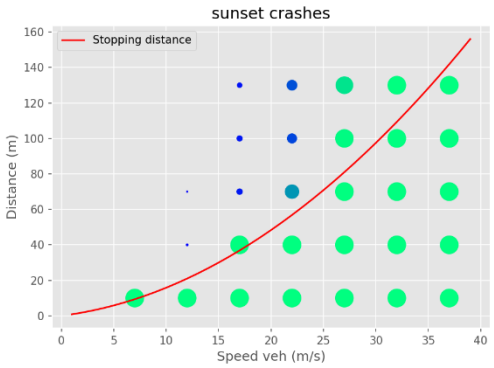
Crashes for low resolution Thermal camera

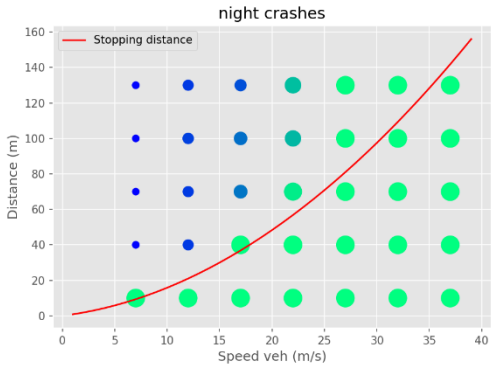
Low Resolution thermal camera



Low resolution thermal camera improves system detection performance in sunset and night conditions







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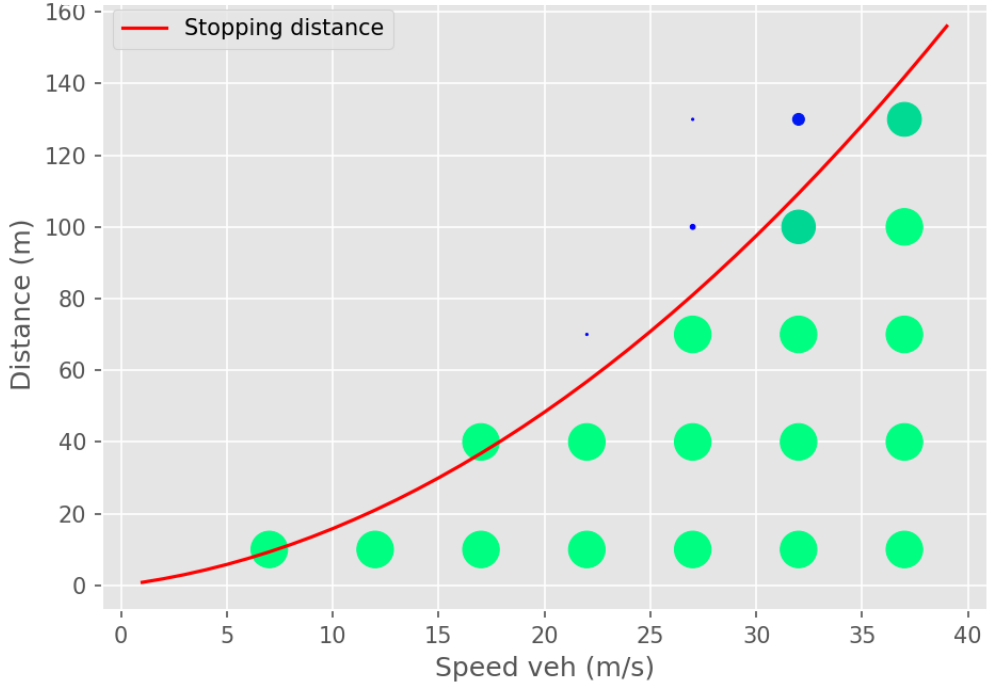
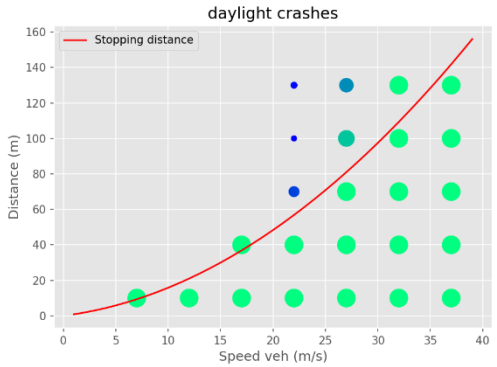
Crashes for High resolution Thermal camera

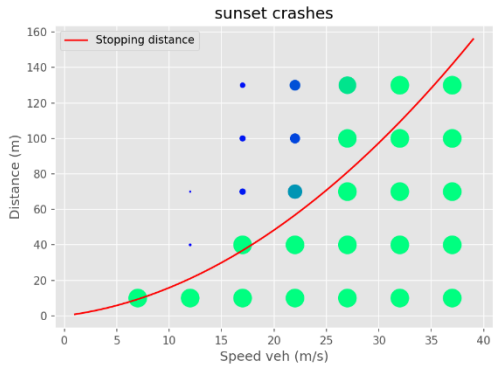
High Resolution thermal camera

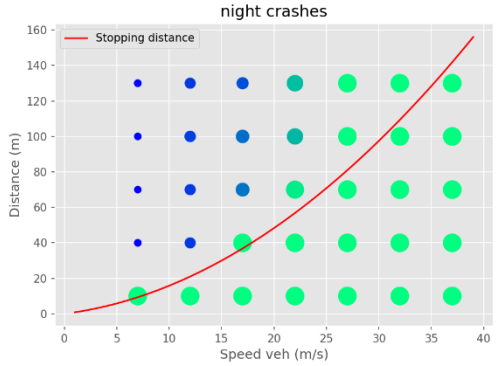


The number of crashes for the High-resolution cameras is close to the base scenario.

It improves the daytime performance of the visible camera and extend them to night conditions







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Conclusion

Conclusions

Thermal cameras (especially high resolution one) proved very effective **up to 150m detection**

Low Resolution Thermal cameras can **prevent pedestrian collisions** in urban conditions

High-resolution thermal cameras would be needed **for higher speeds (>65km/h) and Autonomous Vehicles applications**

More research is needed for the visible light cameras, although in night conditions their capacity decreases

Thank you

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