# LED: Light Enhanced Depth Estimation at Night

Simon de Moreau[1,2], Yasser Almehio[2], Andrei Bursuc[3], Hafid El-Idrissi[2], Bogdan Stanciulescu[1], Fabien Moutarde[1]

[1] Mines Paris - PSL University, [2] Valeo, [3] Valeo AI

## Main Takeaways

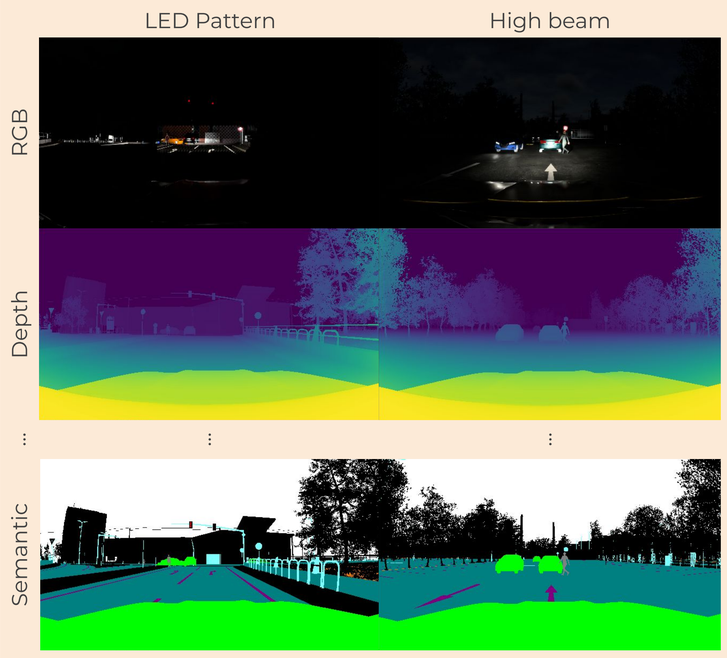
- **Light Enhanced Depth (LED)** is a **cost-effective** method that harnesses **high-definition headlights' pattern** to **enhance nighttime depth estimation** from RGB images.
- **LED improves** nighttime performances of **any depth estimation architecture.**
- **LED** demonstrates **great performances improvements on our real-world car-mounted prototype.**
- We release the **Nighttime Synthetic Drive Dataset (NSDD)**, comprising 49,995 comprehensively annotated nighttime images

**Project page** **Code**

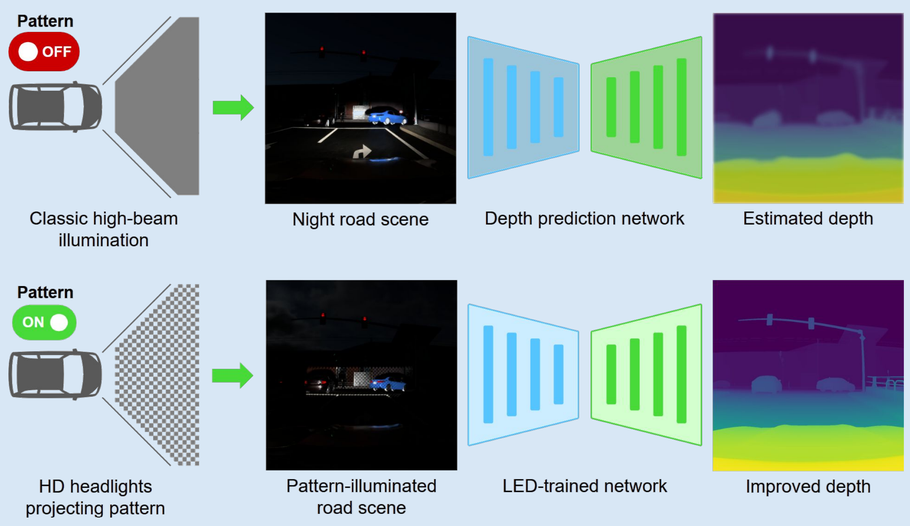
## Motivation

- **Nighttime** camera-based **depth estimation** is a **highly challenging** task.
- Current solutions rely on **expensive sensors** (e.g., LiDAR).
- Vision **foundation models** are **unreliable in low-light conditions.**

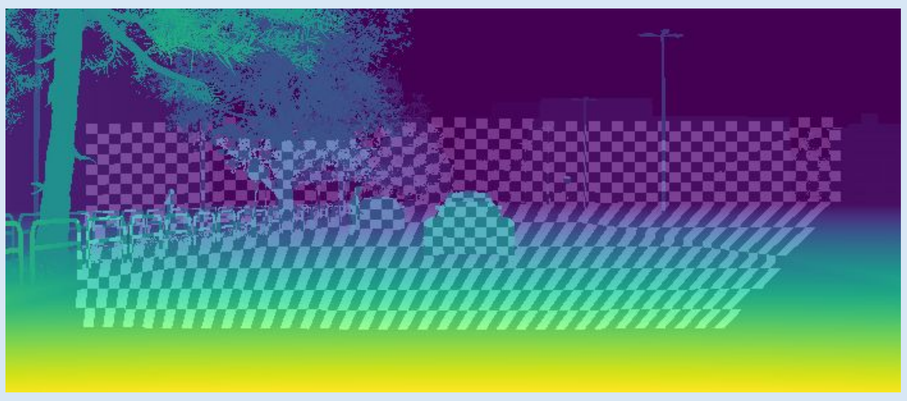
## Nighttime Synthetic Drive Dataset



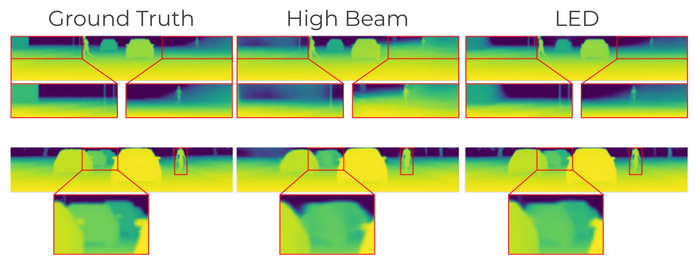

## Method




- Projected pattern **deformations** provide **guidance** to the network and **cues about the scale and geometry** of the scene.
- **The reference pattern is implicitly learned** by the network during training.
- **Checkerboard pattern** contains **features** easily learnable by **CNN architectures.**



## Results on NSDD

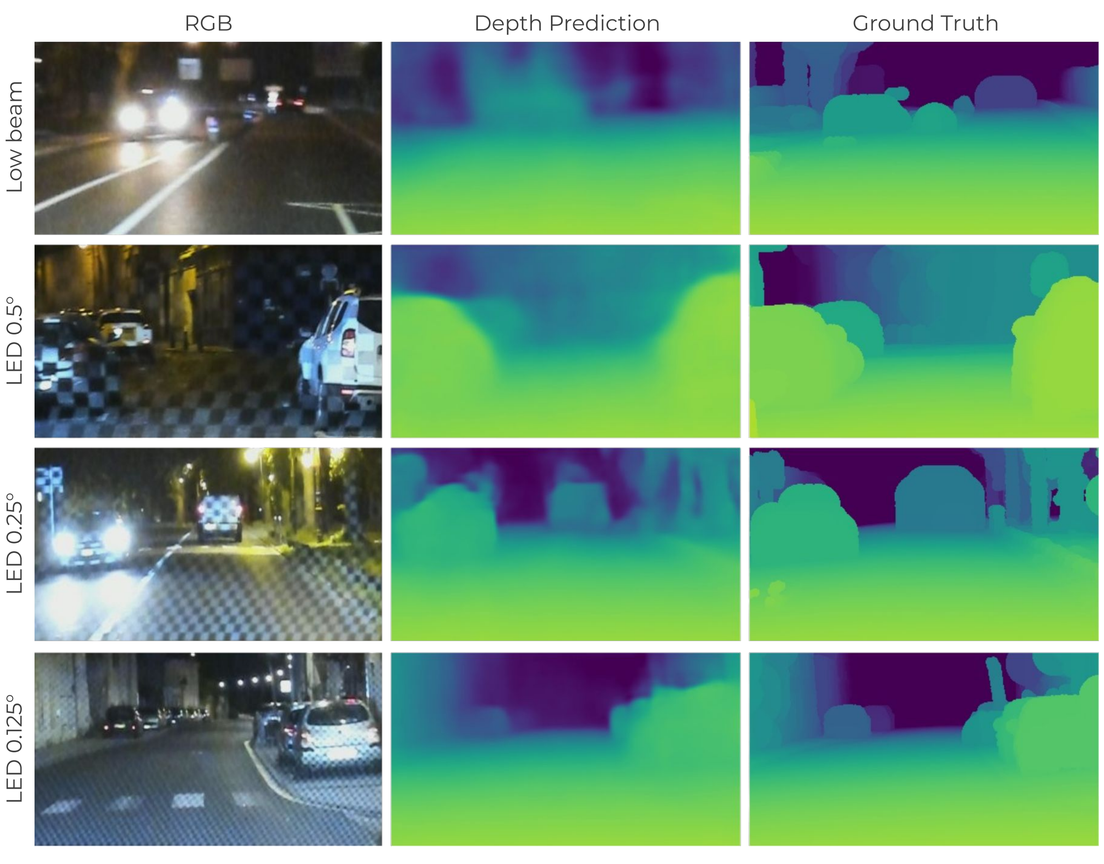



| Pattern | RMSE ↓ | Abs Rel ↓ | SILog ↓ |
|---|---|---|---|
| *Encoder-decoder* | | | |
| HB | 6.1204 | **0.0903** | 13.4847 |
| LED | **5.4259** | 0.1996 | **12.4900** |
| *Adabins* | | | |
| HB | 7.3520 | 0.1360 | 10.1880 |
| LED | **5.5830** | **0.0690** | **7.7290** |
| *DepthFormer* | | | |
| HB | 5.8528 | **0.0687** | 11.3841 |
| LED | **5.3845** | 0.1215 | **10.4146** |

## Depth Anything V2 on NSDD

| Pattern | # Images | RMSE ↓ | Abs Rel ↓ | SILog ↓ |
|---|---|---|---|---|
| HB | Zero-shot | 19.058 | 0.430 | 27.004 |
| LED | | **18.023** | **0.420** | **25.500** |
| HB | 100 | 6.499 | 0.075 | 12.894 |
| LED | | **6.198** | **0.073** | **12.182** |
| HB | 500 | 5.447 | 0.058 | 10.629 |
| LED | | **5.225** | **0.057** | **10.038** |
| HB | 1000 | 5.124 | 0.058 | 10.038 |
| LED | | **4.328** | **0.044** | **8.374** |

## Real-world Results




| Pattern | RMSE ↓ | Abs Rel ↓ | SILog ↓ |
|---|---|---|---|
| *Encoder-decoder* | | | |
| LB | 14.199 | 0.187 | 28.938 |
| LED 0.5° | 11.089 | 0.119 | 21.251 |
| LED 0.25° | **8.695** | 0.109 | **18.635** |
| LED 0.125° | 10.154 | **0.096** | 18.862 |
| *DepthFormer* | | | |
| LB | 8.777 | 0.138 | 17.170 |
| LED 0.5° | 6.810 | 0.101 | 14.380 |
| LED 0.25° | **5.621** | 0.082 | 11.735 |
| LED 0.125° | 5.727 | **0.076** | **10.754** |
| *DepthAnythingV2 - 1000 training images* | | | |
| LB | 7.637 | 0.104 | 14.617 |
| LED 0.5° | 7.017 | 0.109 | 14.044 |
| LED 0.25° | 6.304 | 0.102 | 12.300 |
| LED 0.125° | **5.785** | **0.082** | **10.673** |

## Studies