4D SOLID-STATE LIDAR UTILIZING VCSEL AND SPAD ARRAYS

EPIC Meeting on LIDAR Technologies for Automotive
Anteryon | Eindhoven | 2019-10-31
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Why it’s hard to build a solid-state LiDAR

Dokumentenklasse: public
Specialized in the field of automotive LiDAR Sensors

Employees
- 380+ (2019)

Offices
- Hamburg, Germany (Headquarters)
- Eindhoven NL, Detroit USA, China (coming soon)

Partnership with Valeo in automotive serial production

“too bulky”
“too expensive”
“limited vertical FOV”
NEXT GENERATION LIDAR REQUIREMENTS

“too bulky”
“too expensive”
“limited vertical FOV”

solid-state
- high resolution: $0.1^\circ \times 0.1^\circ \ (H \times V)$
- wide FOV: $120^\circ \times 20^\circ \ (H \times V)$
- long range: $300\text{m} \ (80\text{m} \ 10\%)$
- frame rate: $25 \text{Hz}$
- fast: in 2020 (2022)
- cost efficient and automotive qualified

$\Delta t_{300\text{m}} = \frac{2 \cdot 300 \text{ m}}{3 \times 10^8 \text{ m s}^{-1}} = 2 \mu\text{s}$

$\frac{40 \text{ ms}}{2 \mu\text{s}} = 20000$

- e.g. $500 \times 40$ Points

$\Rightarrow$ scanning FOV point-wise is not feasible
SOLID-STATE SCANNING

How to **solid-state** but **wide FOV** and **high resolution**?

spectral deflection

OPA

MEMS mirror
FOCAL PLANE ARRAY

Power hungry (optical) with
• technical and
• eye-safety limitations
\[ E_{\text{Pulse,905\,nm}} \approx 100\,\text{nJ} \] (DIN EN 60825)

Array of emitter
→ no edge emitter but VCSELs

Focal Plane Array (FPA)

Map receiver to emitter
→ enhanced optical power budget
FOCAL PLANE ARRAY
SOLID-STATE SCANNING
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small VCSEL pixel ➔ small output power
SINGLE PHOTON AVALANCHE DIODE (SPAD)

- small VCSEL pixel ➔ small output power
- utilize SPADs instead of linear photodetectors
- classical time-of-flight not possible
CLASSICAL TIME-OF-FLIGHT
CLASSICAL TIME-OF-FLIGHT

\[ d = \frac{c\Delta t}{2} \]
SPADS

small VCSEL pixel ➔ small output power
➔ utilize SPADs instead of linear photodetectors
➔ classical time-of-flight not possible

single-photon avalanche diodes (SPADs)
➔ binary detection, i.e. trigger devices (what is signal/noise?)
➔ repeat measurements (build histograms)

➔ time-correlated single-photon counting (TCSPC)
with new DSP possibilities in the automotive market
TCSPC - DSP

intensity

# of hits

# of bin
TCSPC - DSP

- intensity
- background light
- target properties (pulse shape)
- weather conditions

# of hits

# of bin
### SUMMARY

**Why it’s hard to build a solid-state LiDAR**

Requirements are tough

<table>
<thead>
<tr>
<th>solid-state</th>
<th>wide FOV</th>
<th>frame rate</th>
<th>cost efficient and automotive qualified</th>
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<tbody>
<tr>
<td>high resolution</td>
<td>long range</td>
<td>fast</td>
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**One way to do it**

Truly solid-state LiDAR

Allows for advanced signal processing
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