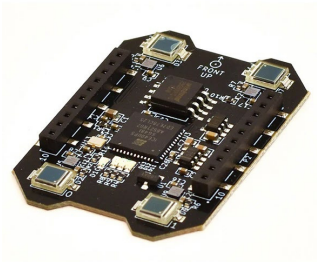
Lighthouse Positioning System

From Virtual Reality to Onboard Positioning for Robotics



bitcraze

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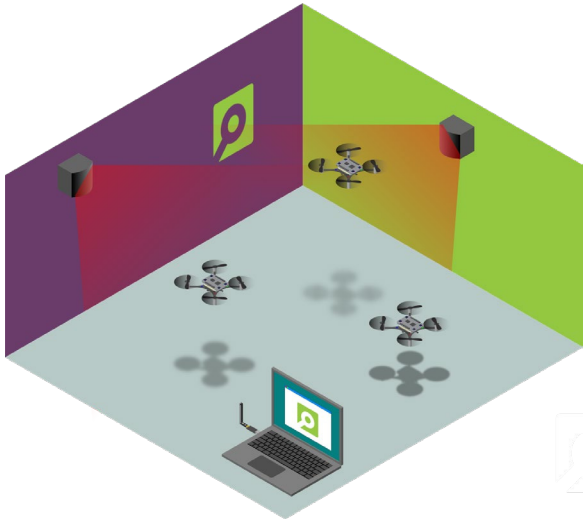
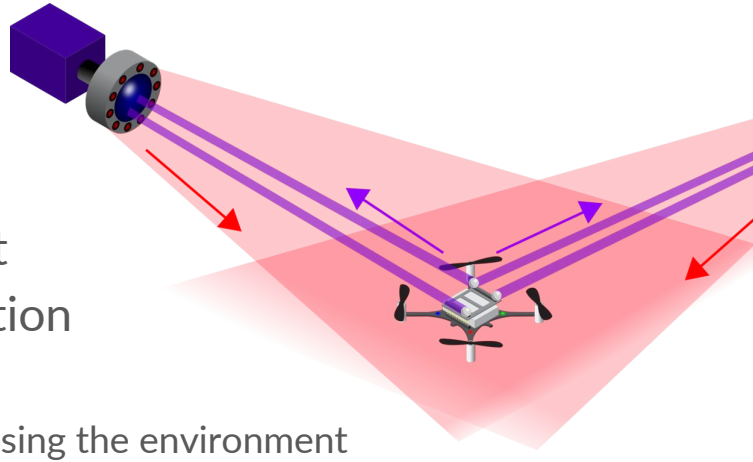


- Small company
  - South of Sweden
  - Since 2012
- Developer of
  - Crazyflie quadcopter
  - Ecosystem
- Open-source software, documented hardware
- Expandable, modular & hackable platform
  - Expansion decks
  - Intended to be used for research and development

Positioning in Robotics



- Major part of robotics research in development
- Moving robots needs to know about their position
- In real life application
  - SLAM: positioning using cameras and other sensor sensing the environment
  - Odometry: Wheels or optical flow
  - Radio/beacon based positioning. GPS, Bluetooth, wifi, UWB
- In the lab, we need ground truth
  - Motion capture
  - Replacement for GPS in Mobile or Aerial Robotics
- Getting position offboard the robot V.S. Getting position onboard in the robot

Origin: SteamVR™ positioning system

- Designed by Valve:
  - track headset and hand controller
  - Virtual Reality purposes
- Low latency and great relative accuracy
- Base Stations placed near room ceiling
- 2 Versions:
  - V1 limited to 2 base stations
  - V2 supports 4 base stations, designed for up to 16

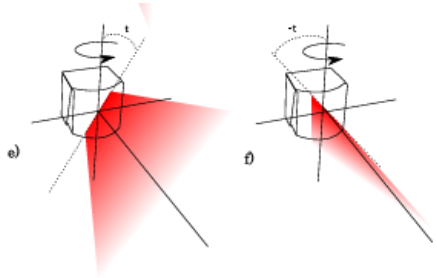
Picture by HTC Vive

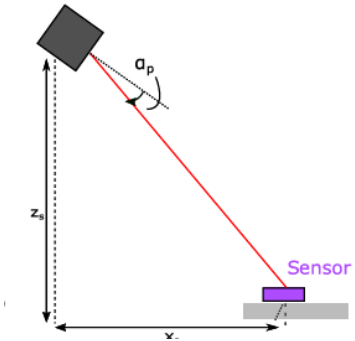
The Lighthouse Positioning System

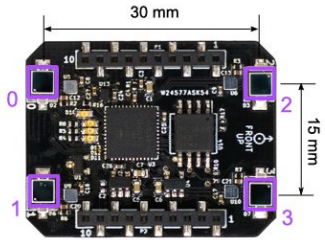
- V1 and V2 system reverse engineered
- Implementation as a positioning system for the Crazyflie 2.1 quadcopter
- Supports up to 4 base stations, similar to Valve implementation

Lighthouse positioning

- Lighthouse Base stationRotating drum
  - Infrared Laser plan on Rotating drum
  - Sweeps through covered space
- Receiver (Lighthouse) deck
  - Photodiodes
  - Receive the IR sweeps
- Time synchronized
  - Synchronization encoded in laser plane
- Receiver calculate angles
  - Receive time of the sweeps
- Extended Kalman filter
  - Onboard STM32F4 processor on the Crazyflie





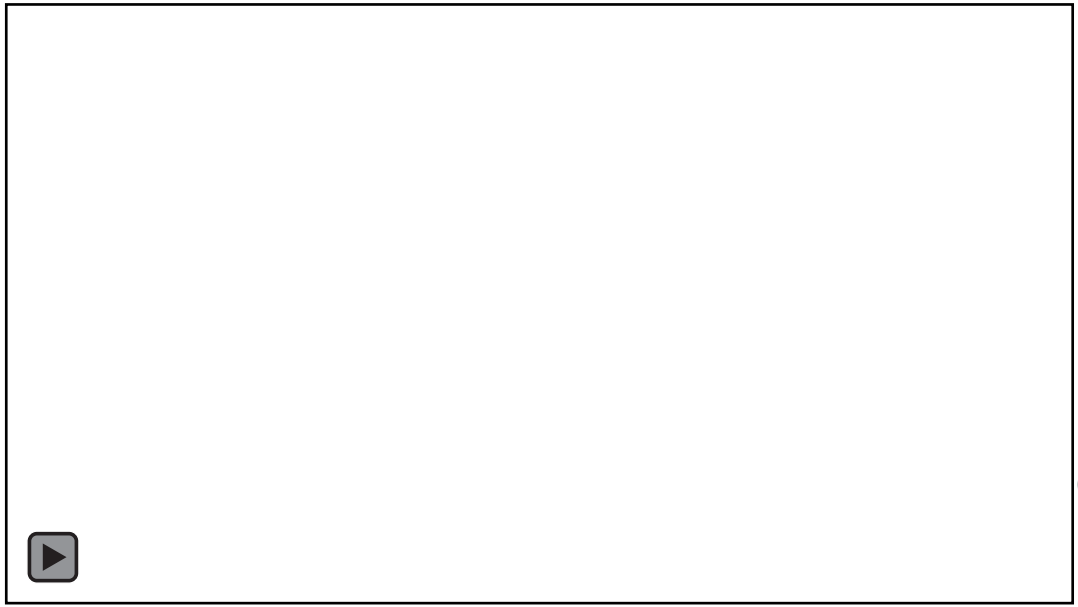


https://www.bitcraze.io/documentation/system/positioning/ligthouse-positioning-system/

Use on a nano drone: The Crazyflie 2.1

Motion Capture (Qualisys)

UWB positioning



Lighthouse Positioning

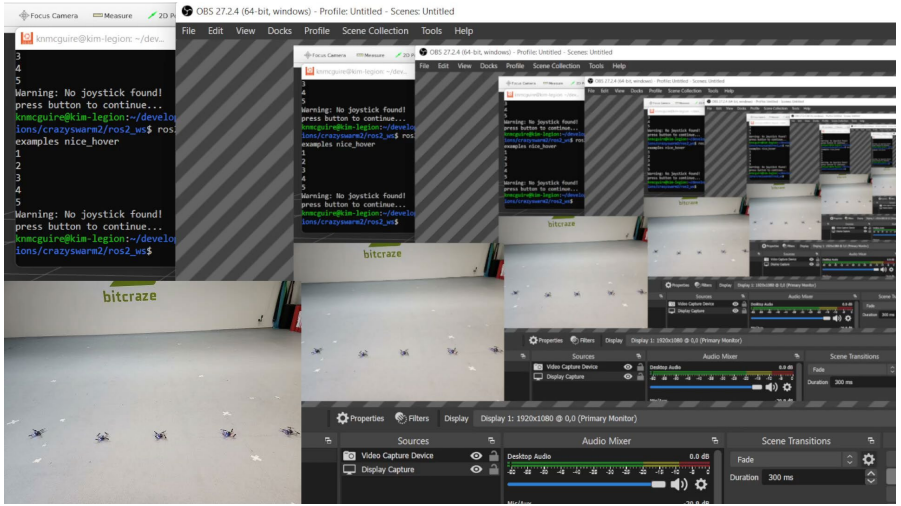
Optical Flow

https://youtu.be/E2Pj2YCRjHg

Lighthouse Positioning System: Dataset, Accuracy, and Precision for UAV Research, Robot Swarms in the Real World Workshop at ICRA, 2021, A. Taffanel et al

ROS integration

- Onboard positioning on Microprocessor
  - No ROS 2 onboard
  - MicroROS ??
- Getting positioning from directly from Crazyflie API -> ROS
  - ROS 1 - Crazyflie_ros, Crazyswarm*
  - ROS 2 - Crazyswarm 2**
- ROS 2 mapping at Booth 21***



https://youtu.be/w99hLldcSp4

* https://crazyswarm.readthedocs.io/
** https://imrclab.github.io/crazyswarm2/
*** bitcraze.io/events/roscon2024

Use for general robotic

- Affordable system makes research more accessible
- Opposite trade-off compared to MoCAP:

	Motion Capture	**Lighthouse**
Installation and setup	Hard (Better for Fixed setups)	Easy (Ideal for demos)
Cost per setup	High	Low
Cost per tracked object	Just add reflectors	Needs a full receiver board
Object identification	Unique marker combination, Active encoded IR LEDs	Positioning onboard, No unique ID necessary
Tracking from outside (ground truth)	Position is known offboard	Position needs to be shared offboard

Current state of the Lighthouse Positioning system*

- *Meaning, the state of inhouse development at Bitcraze
- Lighthouse Base stations still widely available
- Up to 4 basestion proven to work well with the Crazyflie platform
- Support of up to 16 base stations in the making.
- Support for a stand alone board in the making

Other platforms then the Crazyflie?

- Inhouse hack Pololu RPI+ 2040
  - Crazyflie Bolt + Lighthouse deck
- INRIA-AIO
  - Made their own receiver
  - Check out their paper*
- Other
  - Cronos from ETH Zurich**
  - Andino from Ekumen (in the works)
- Come talk to us!
  - Would this be interesting to use on your robot?

* Alvarado-Marin, Said, et al. "Lighthouse Localization of Miniature Wireless Robots." *IEEE Robotics and Automation Letters* (2024).
** Bodmer, Sabrina, et al. "Optimization-Based System Identification and Moving Horizon Estimation Using Low-Cost Sensors for a Miniature Car-Like Robot." *arXiv preprint arXiv:2404.08362* (2024).

Questions?

More info at bitcraze.io/events/roscon2024

www.bitcraze.io
contact@bitcraze.io

Live demos at booth 21