Helmet Cam

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Integrated systems

Design Goals

1. Do not interfere with core helmet function
2. Assemble basic awareness of space, positions of friendlies foes and bogies
3. Present images of blind spots
4. Triangulate flashes

Image Processing Tasks: (modulo unspecified system requirements)

- Image warping to present all or part of a panoramic image (high power mode?)
- Detection of muzzle flashes and independent motion (low power mode?)
- Identification of friend and foe.
- Simultaneous tracking of multiple objects in visual field (fits in high power mode?).
- (Multi-helmet stereo/triangulation).
- Proprioception --- viewing soldier itself can be used as input device for other computational capabilities?

Image warping

- Requires accurate camera (or sensor) calibration.
- Dependent on actual display format.
- Likely to require auto-calibration for helmets actually in use.
- Simultaneous geo-registration of image? (not easy with nearby 3D structure).

- Cheap solution: Only show view from individual camera.

Detection of muzzle flashes, independent motion?

What is the temporal extent of a muzzle flash? If it is smaller than our desired low power frame-rate, then we need long exposure/integration time.

Algorithms for (independent) motion detection from low frame rate video… systems with multiple frame rates.

Identification of friend and foe.

multi-spectral bar codes? Special optics to recognize them?

Homogeneous Imaging

10 cm resolution @ 100 m

$\delta = A$

$$A = \frac{R}{N}$$

$$\delta\theta = \frac{\lambda}{A}$$

$\delta\theta \geq 0.001$

$\delta\theta$ is pixel limited

Sample System

- 10 cm resolution at 100 m implies 1mrad IFOV
- Conventional pixel pitch of 30 microns implies 30 mm focal length required for optics
- f/1 optics implies 30 mm diameter for lens
- Spot size at object is then 3.25 cm
- Spot size at image is 10 microns (hence detector limited resolution)
- Simple optics will image well over only a few degrees
  - Assume 20^{o}, then need 18 imaging systems around circumference; implies 315 pixels in FPA

Pin wheel Helmet

$A = \frac{r}{n \sin\theta}$

Helmet bandwidth 10 GBPs

ELECTRONICALLY STABILIZED COMPACT "BINOCULAR"

ASSUME DISPLAYS ~ 640 x 480

CAMERAS ~ 6μm PIXELS ⇒ 4mm x 3mm

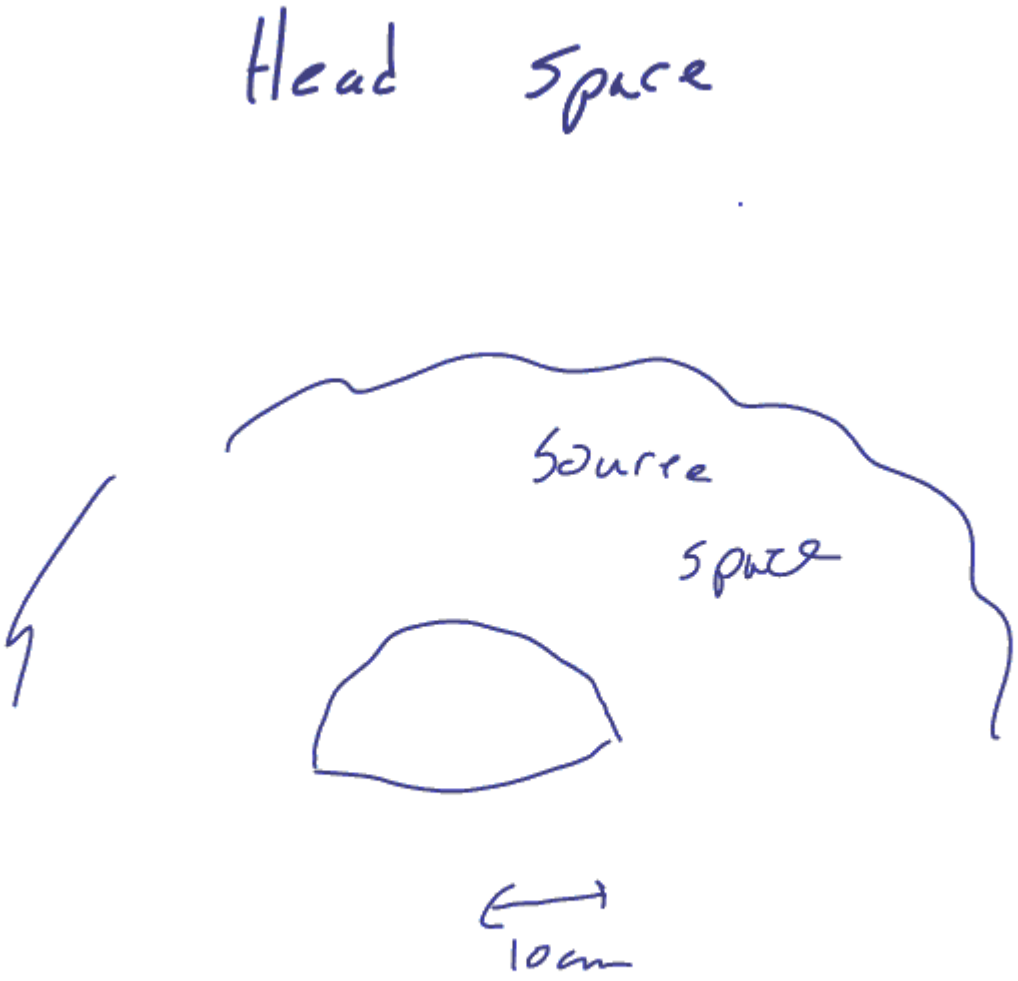
'TYPICAL' LENSE — 6mm FOCAL LENGTH.

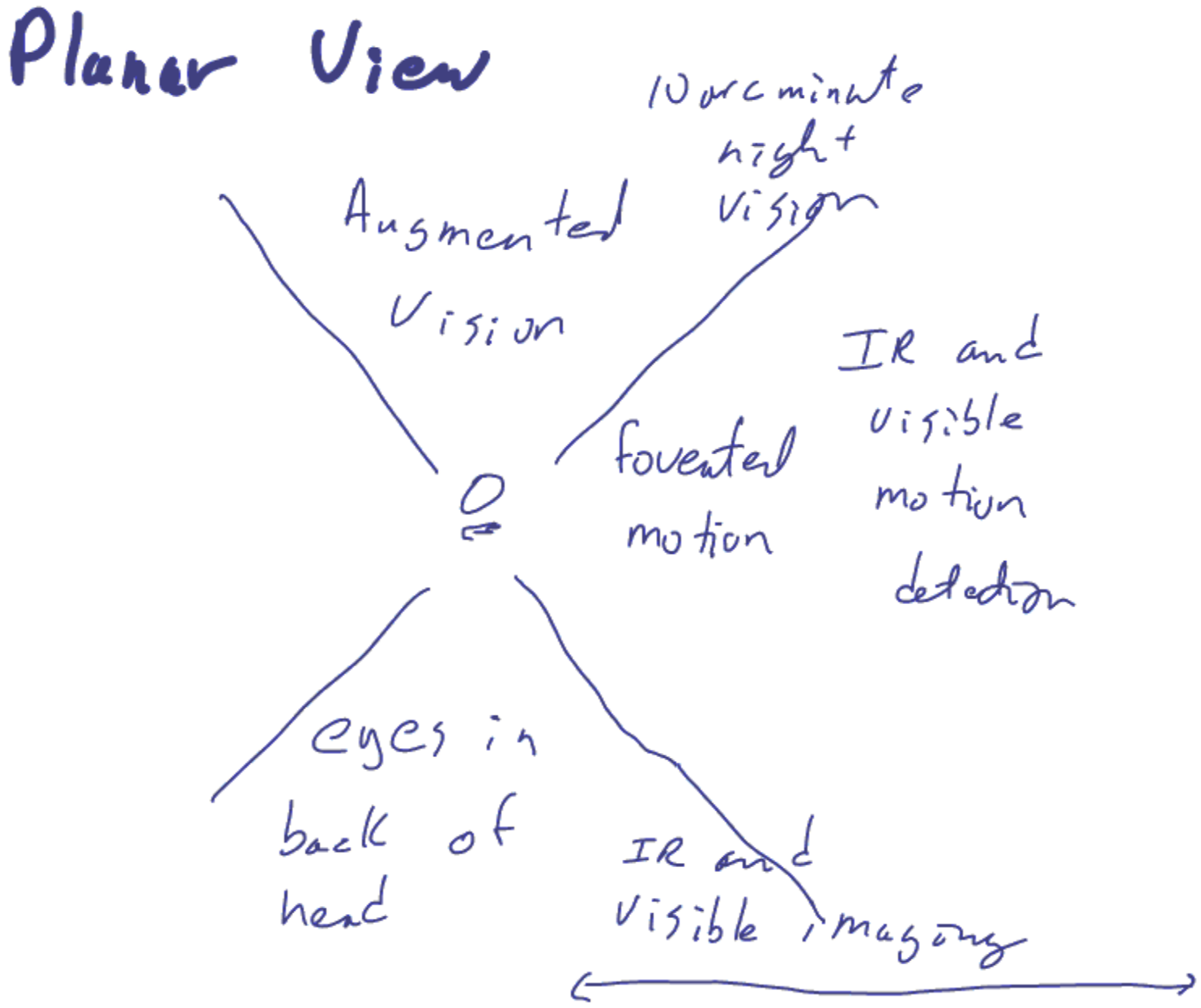
HIGH RESOLUTION = MAGNIFICATION = ZOOM

USE n^2 CAMERAS TO PROVIDE n X MAG.

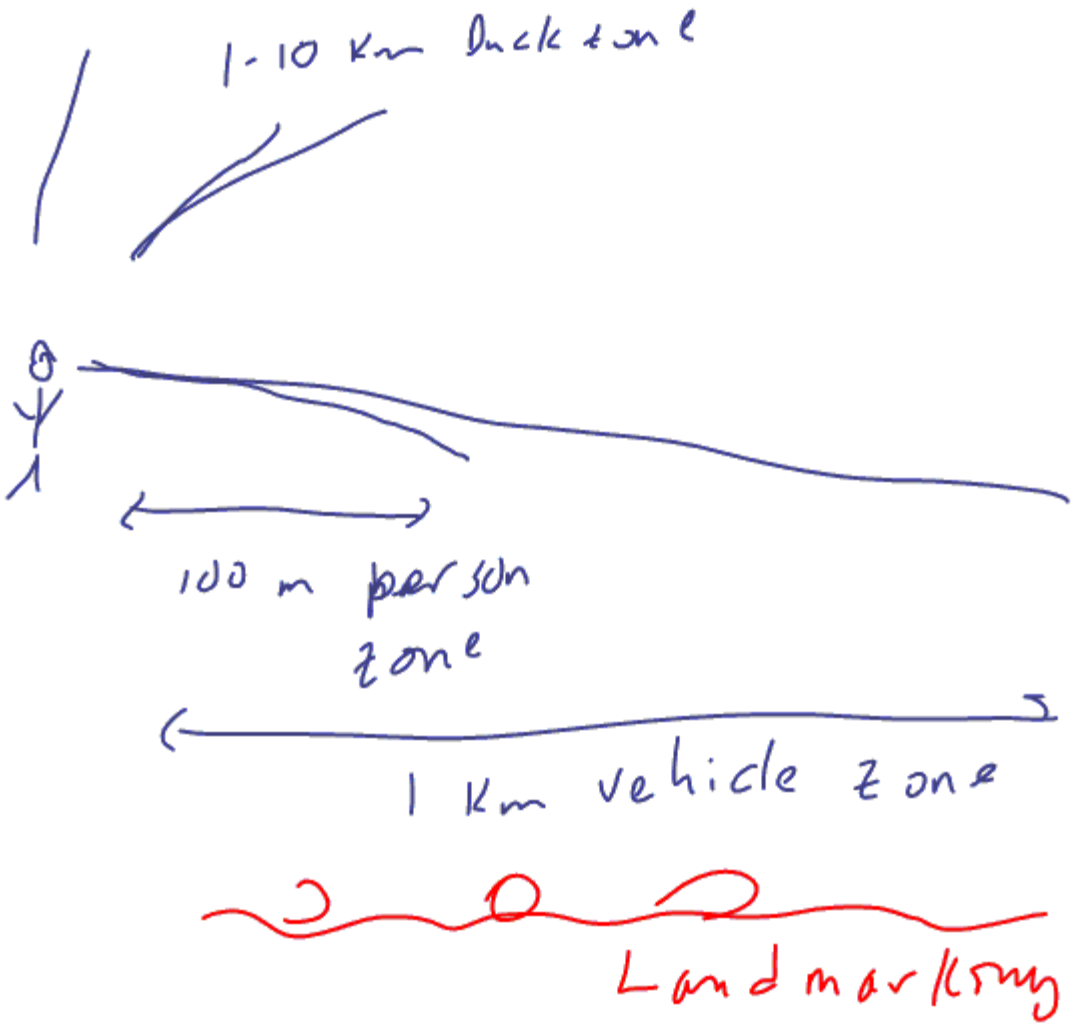
→ 7X BINOCULARS = 49 CAMERAS

ABOUT 1 SQUARE INCH BY 6mm THICK.





Motion, tracking and ID system



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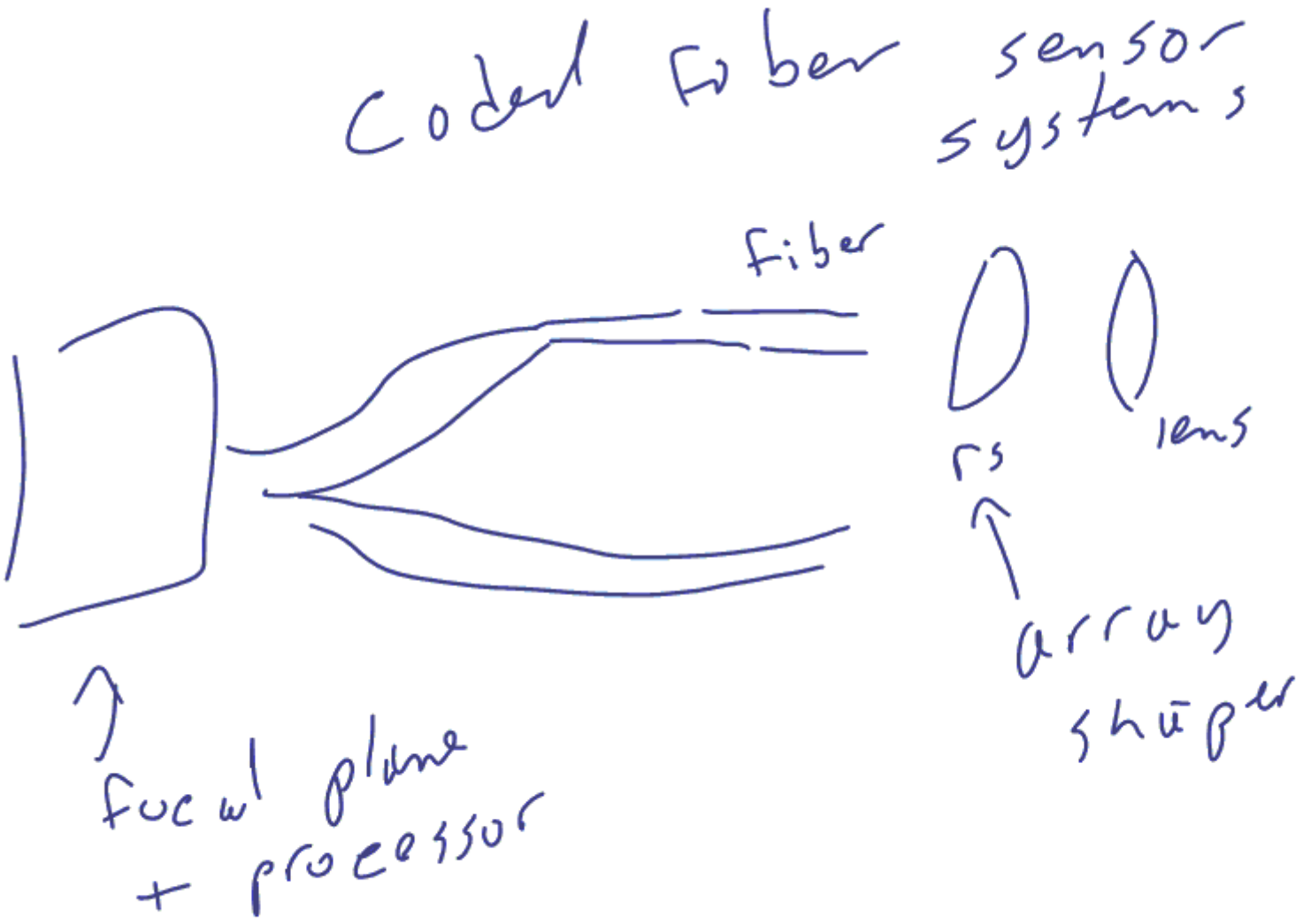
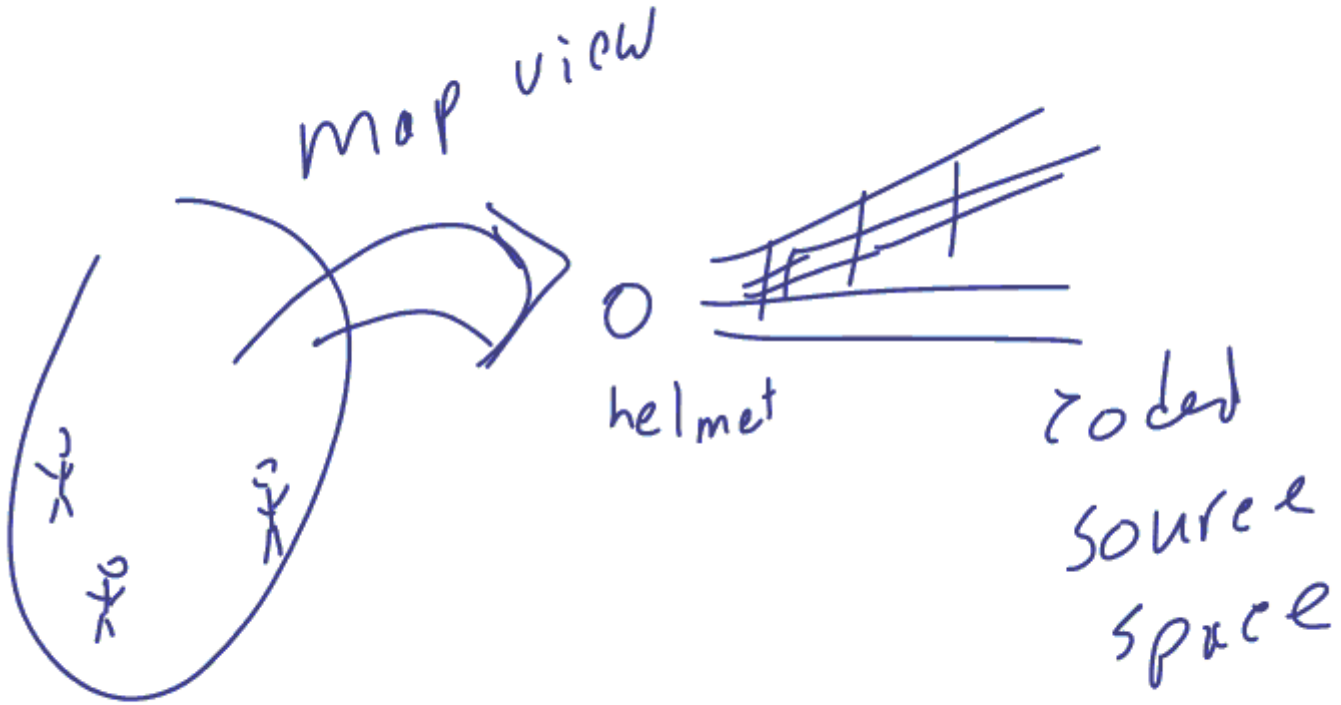
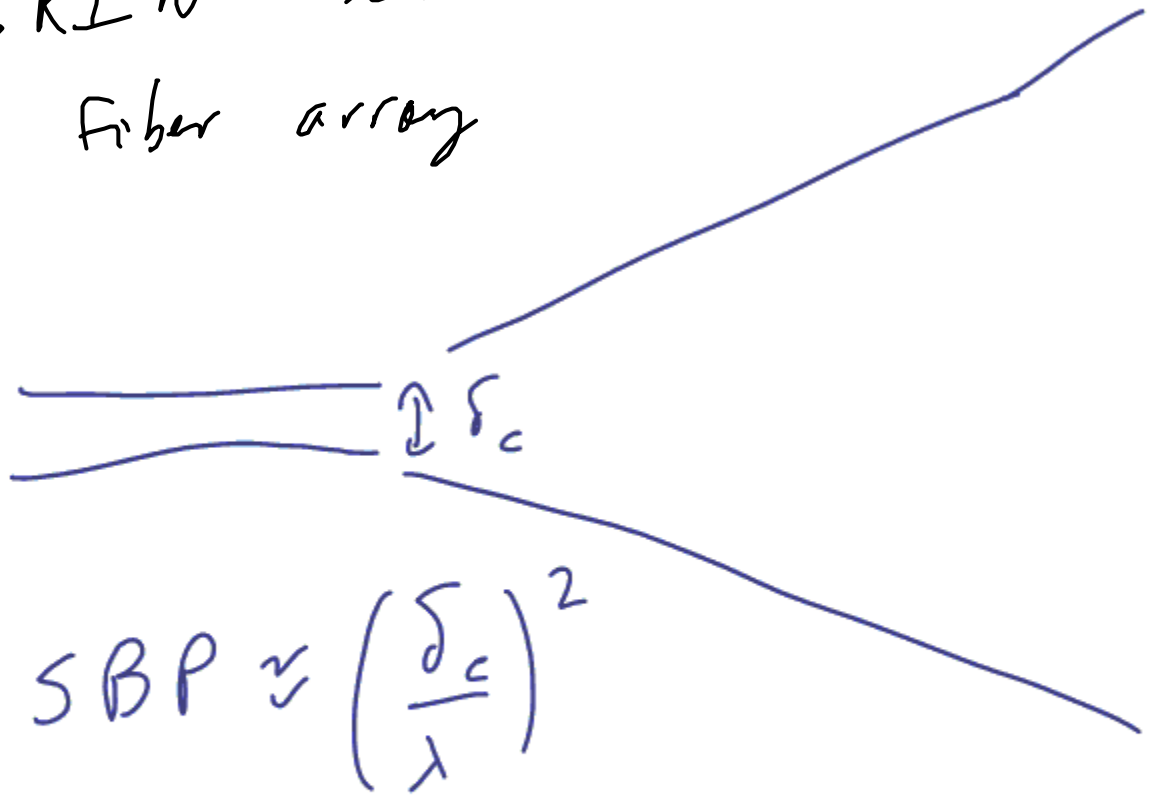




GRIN Selfoc

Fiber array



$$SBP \approx \left(\frac{\delta_c}{\lambda}\right)^2$$

$$\Delta\theta \approx \frac{\delta_c}{\lambda} \approx 0.001$$

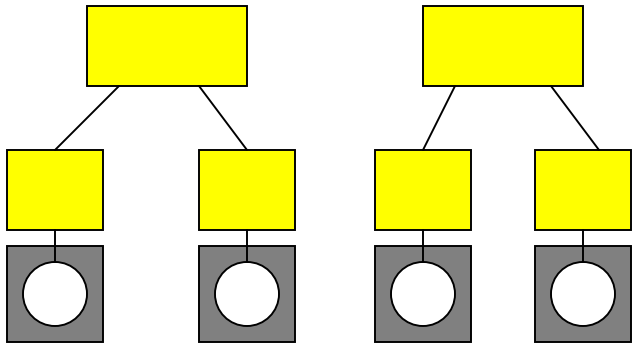
Helmut is $10^{11}\lambda$

fiber coded tracking with 100 detectors?

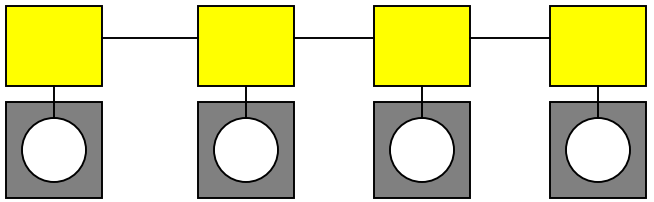
Distributed computer architectures

- Requirements:
  - Low power.
  - Low latency.
  - Small buffer memories.
- Architectural techniques:
  - Distributed processing with dynamic load balancing.
  - Application-specific network.
  - Power management system.

- Alternative network architectures:



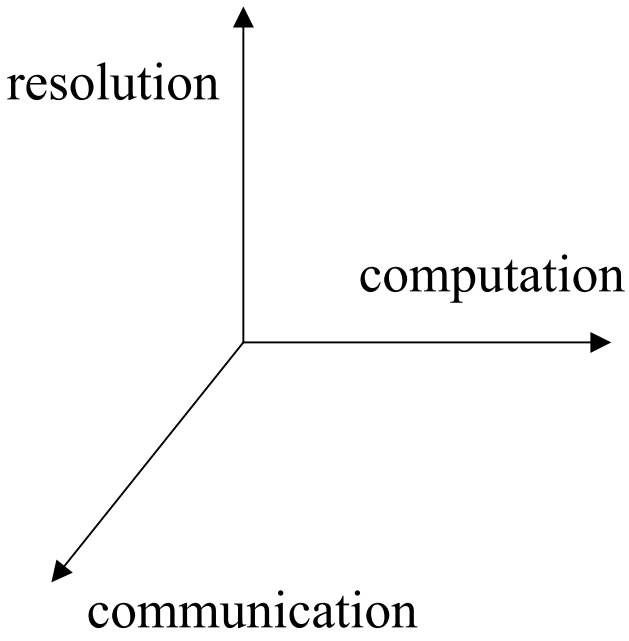
hierarchical



peer-to-peer

Low energy operation

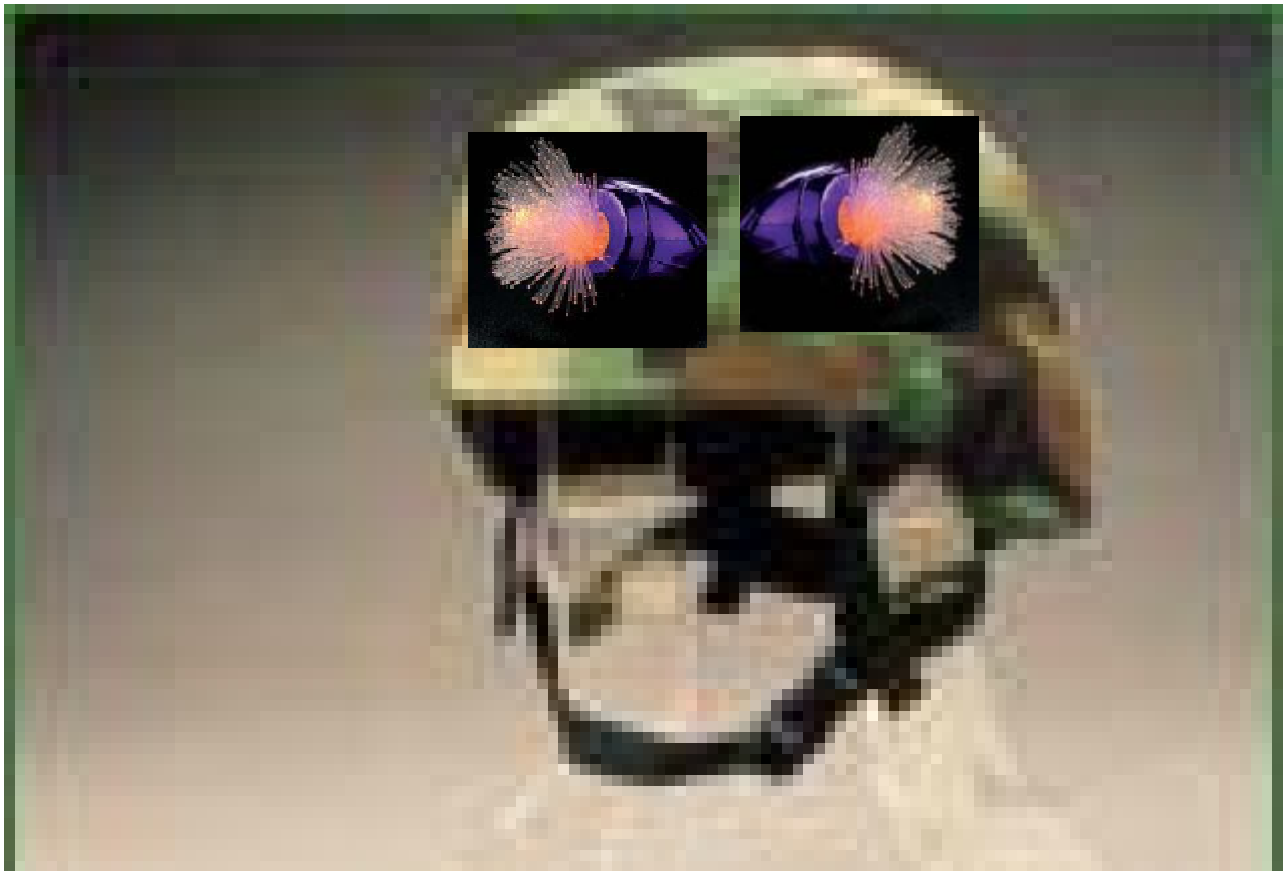
- How to save energy: shut it down, slow it down.
- Architecture must support units that provide a range of energy/performance options.
- Power management system determines what units should be used.
  - Predictive schemes measure past user/environmental behavior, predict usage in the near future.



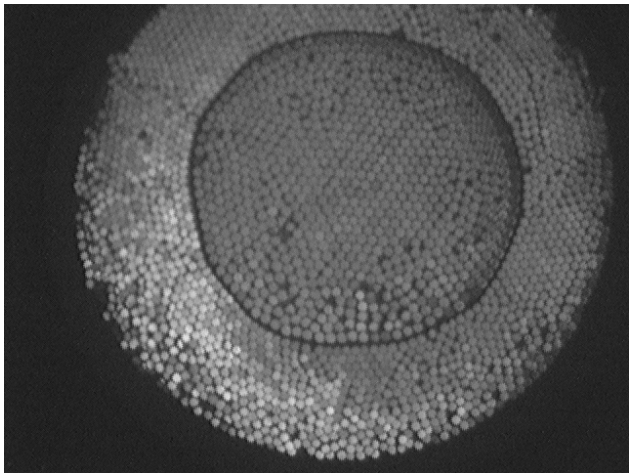
Algorithm/architecture co-design for low energy

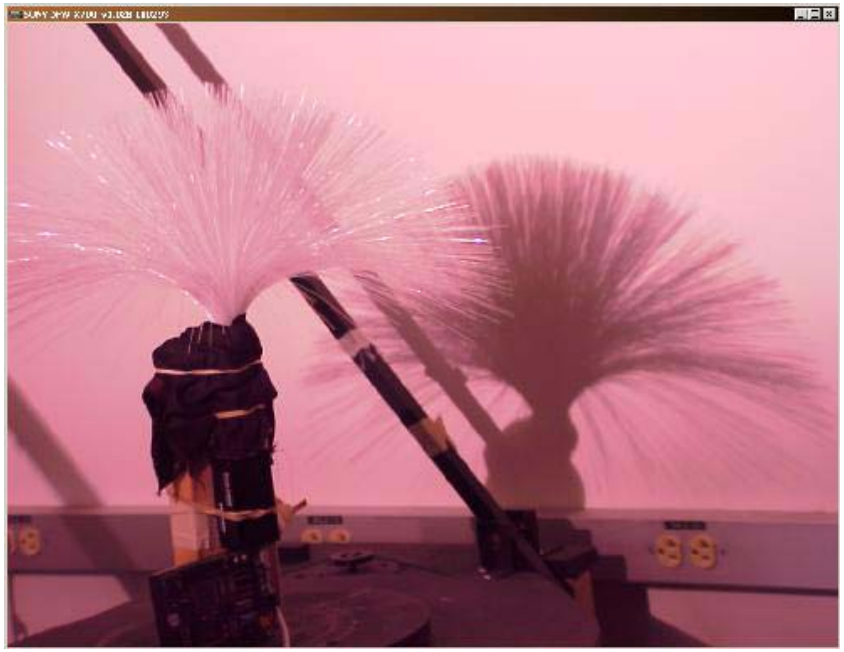
- Trade off algorithmic qualities for energy consumption:
  - Spatial resolution
  - Temporal resolution
  - Desired features
  - Radiation band
- Trade off sensor and computer performance vs. energy consumption:
  - Software vs. hardware vs. optical foveation.

Helmet Cam



Conclusions / Future Work





Critical research challenges.

- → compact IR arrays
- → compact multispectral ; fof sensors / spatio-spectral sensors
- → graceful degradation / system robustness
- → Grating / holographic / PC ID tracking sensing
- → real-time helmet operating systems / low power efficient algorithms
- → How to make information awareness?
- → calibrat

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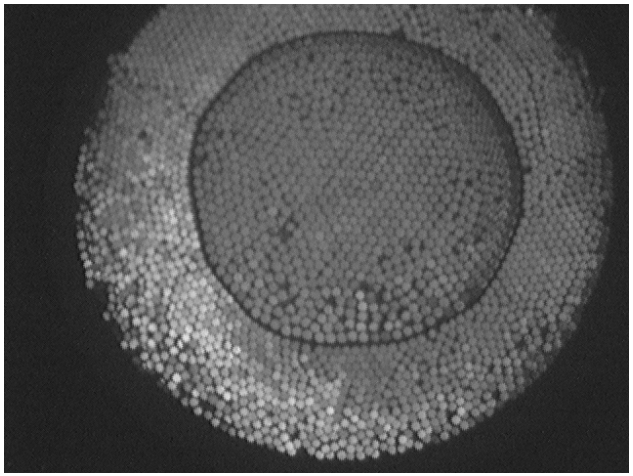

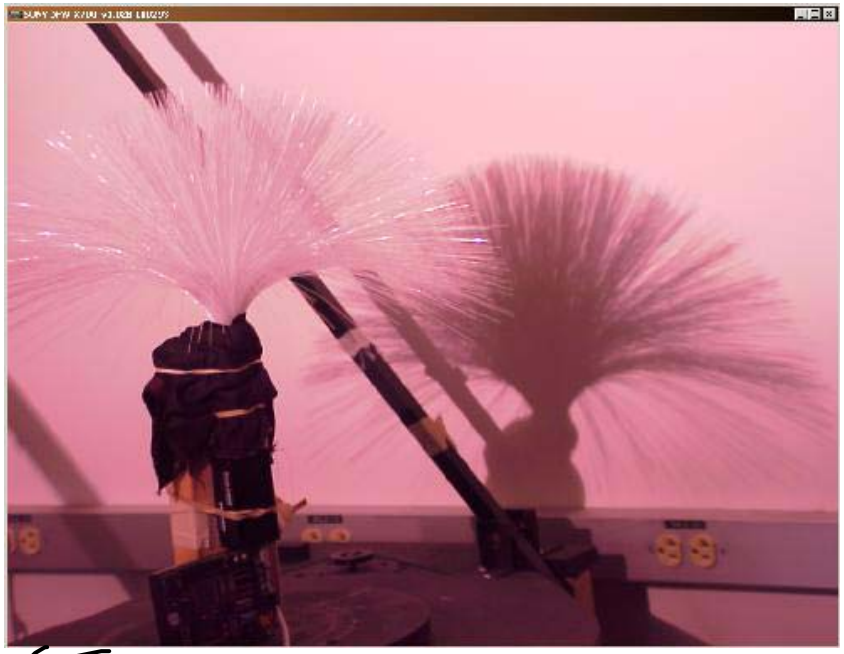

Helmet coordination / Team

→ Robo helmets / Males

Battery / power challenges

Augmented cognition program

→ Exes psychological studies

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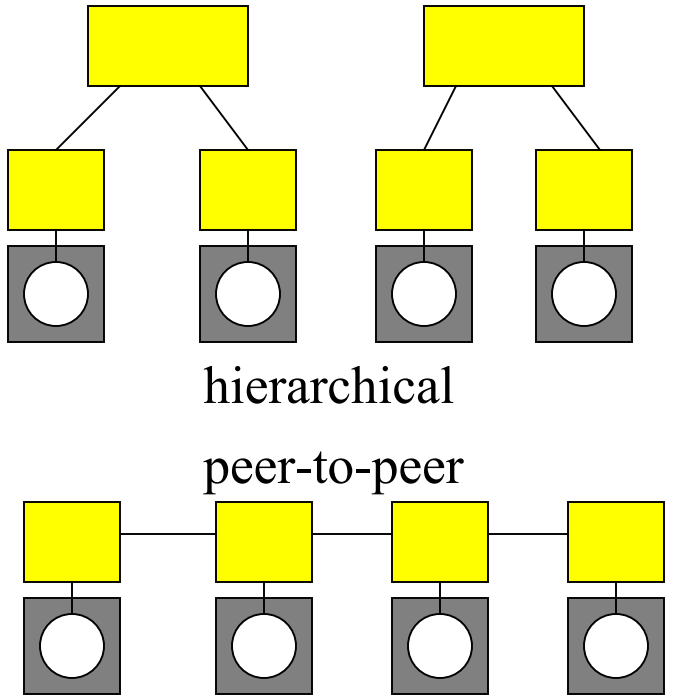

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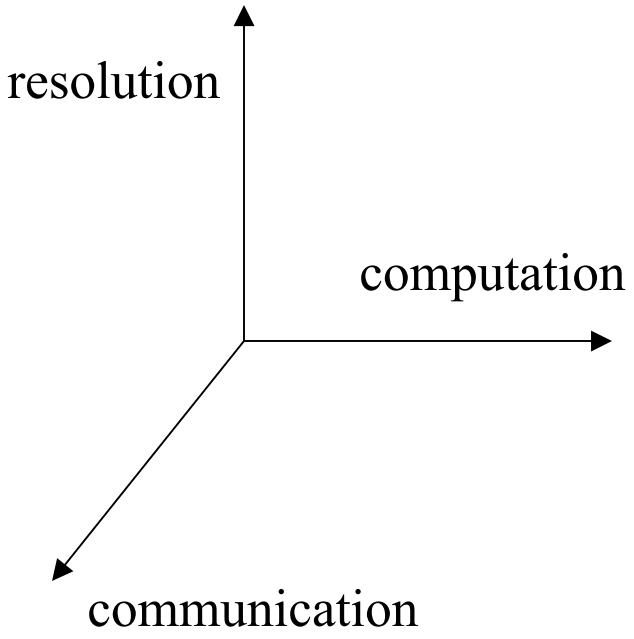

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