



Pico Lantern & Megalodon

Thomas Demarcy, Asclepios Research Team

Edgcumbe, P., Pratt, P., Yang, G.: Pico Lantern: A Pick-up Projector for Augmented Reality in Laparoscopic Surgery. MICCAI 432–439 (2014).

Introduction

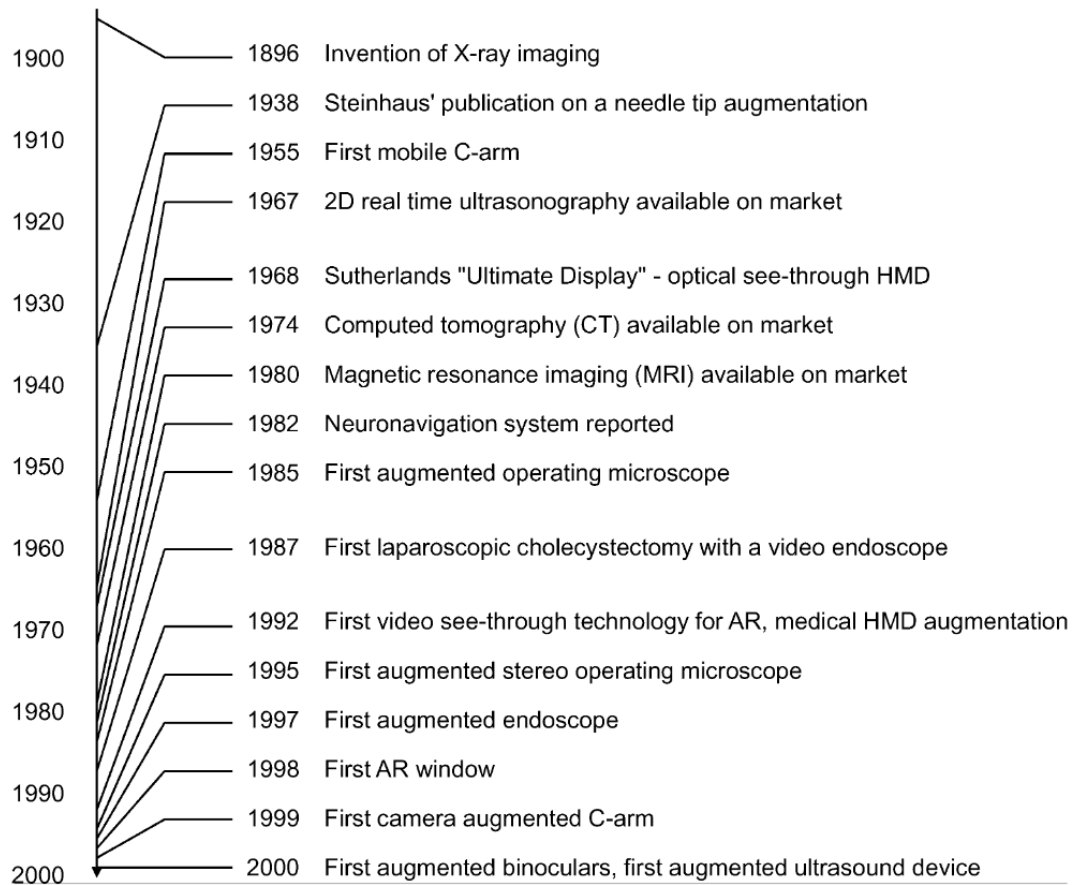
- Doctors are confronted with more imaging data



laparoscopic stomach surgery

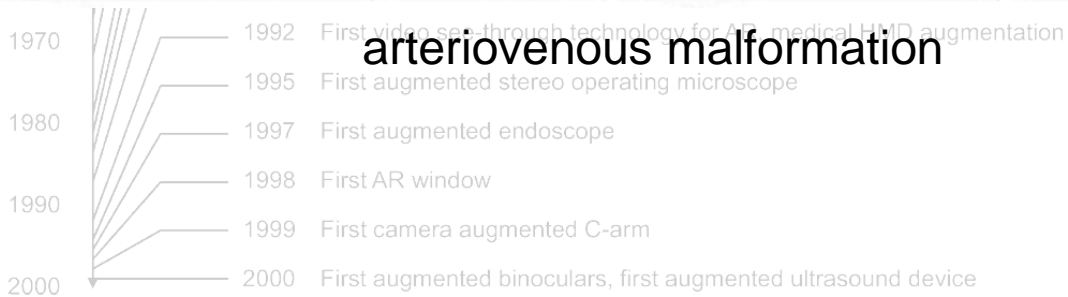
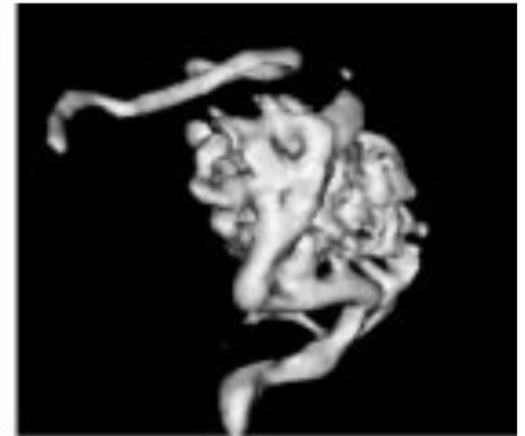
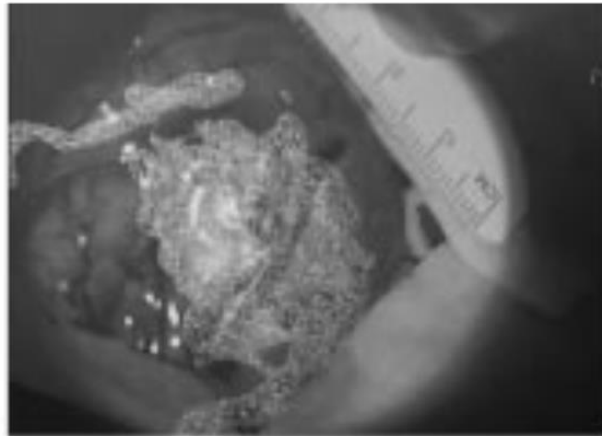
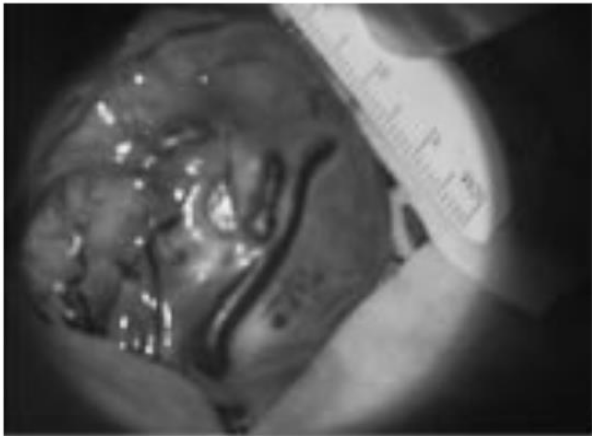
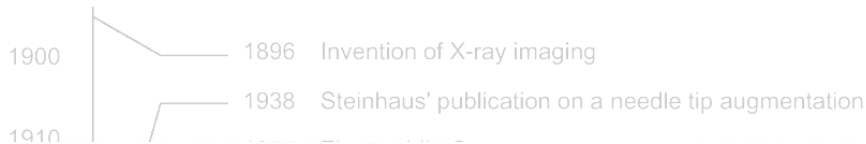
- 3D imaging on 2D screen
- far away from operating situ

Augmented Reality in the Operating Rooms



Sielhorst, T., Feuerstein, M., Navab, N.: Advanced Medical Displays: A Literature Review of Augmented Reality. *J. Disp. Technol.* 4, 451–467 (2008).

Augmented Reality in the Operating Rooms



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Augmented Reality in the Operating Rooms

- Extra Value From Image Fusion
- Implicit 3D Interaction
- 3D Visualization
- Improved Hand-Eye Coordination

Benefits

Sielhorst, T., Feuerstein, M., Navab, N.: Advanced Medical Displays: A Literature Review of Augmented Reality. *J. Disp. Technol.* 4, 451–467 (2008).

Augmented Reality in the Operating Rooms

- Registration, Tracking, and Calibration
- Time Synchronization
- Error Estimation
- Visualization and Depth Perception

Issues

Sielhorst, T., Feuerstein, M., Navab, N.: Advanced Medical Displays: A Literature Review of Augmented Reality. *J. Disp. Technol.* 4, 451–467 (2008).

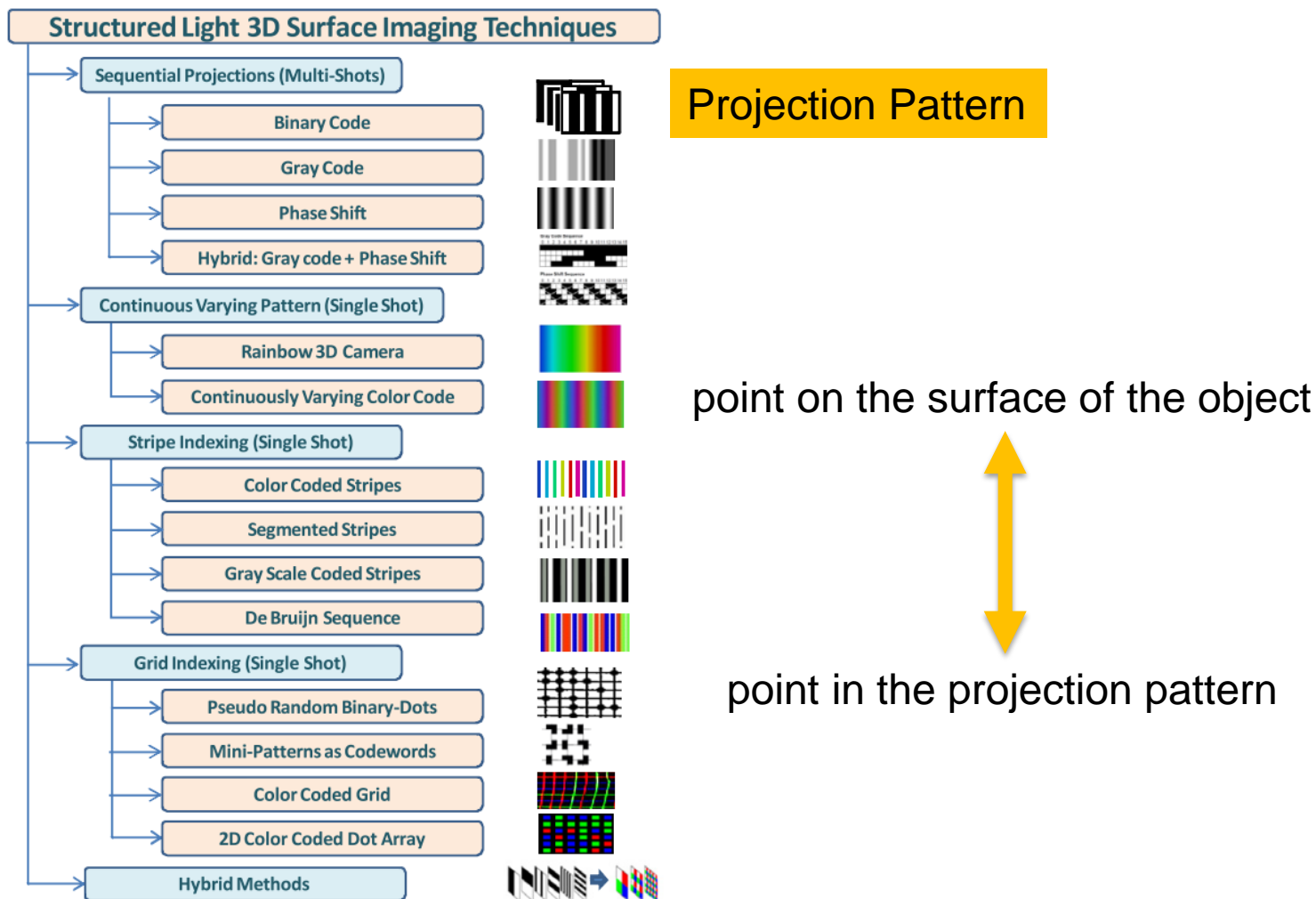
Surface Reconstruction

- Traditional cameras/imaging sensors → 2D images
- Lack the depth information
- Structured light

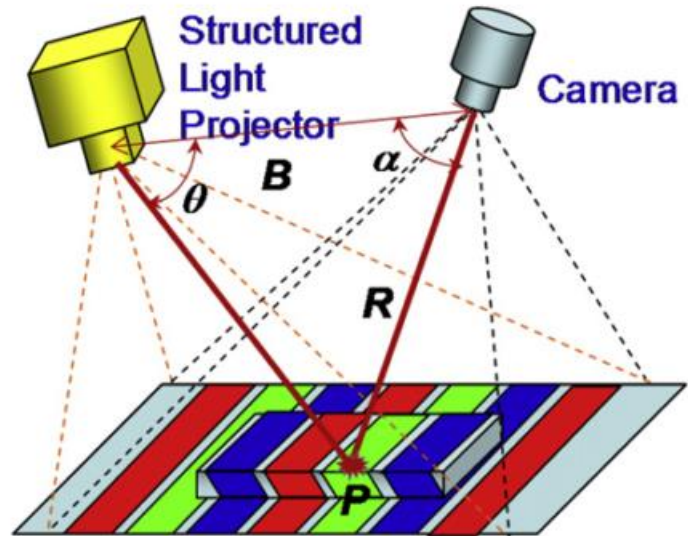
Surface Reconstruction

- Projector + 2D spatially varying intensity pattern
- Imaging sensor acquires 2D image of the scene under the structured-light illumination
- Extraction of 3D surface based on the distortion

Surface Reconstruction



Surface Reconstruction



$$R = B \frac{\sin(\theta)}{\sin(\alpha + \theta)}$$

triangulation

Laparoscopic Surgery

- surgery technique
- abdominal or pelvic cavity
- through small incisions + (monocular) endoscope
- minimally invasive



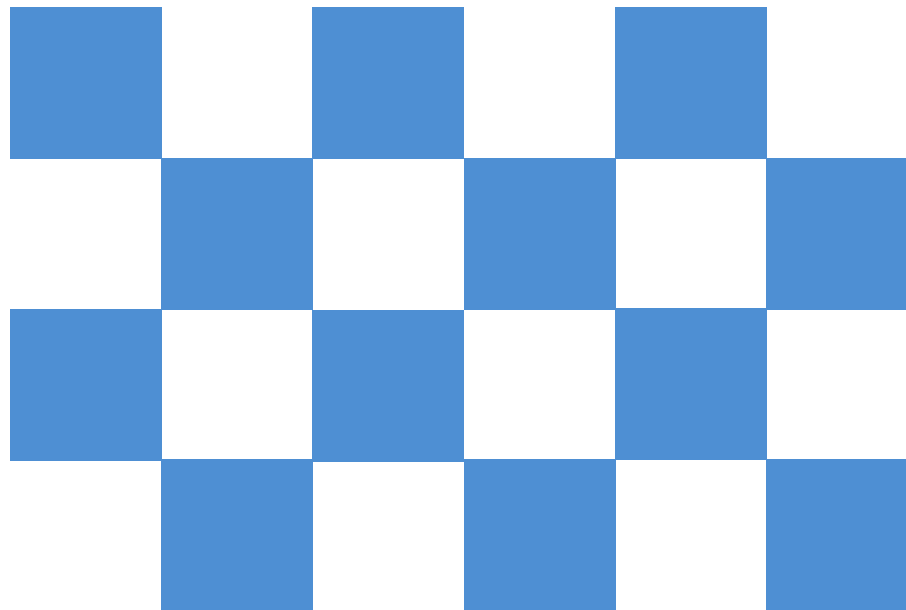
laparoscopic stomach surgery

Pico Lantern

- A **new** combination of **existing** technologies
- recent advances in laser-based pico projectors
- Ø1.7 mm, fit in the biopsy channel of an endoscope

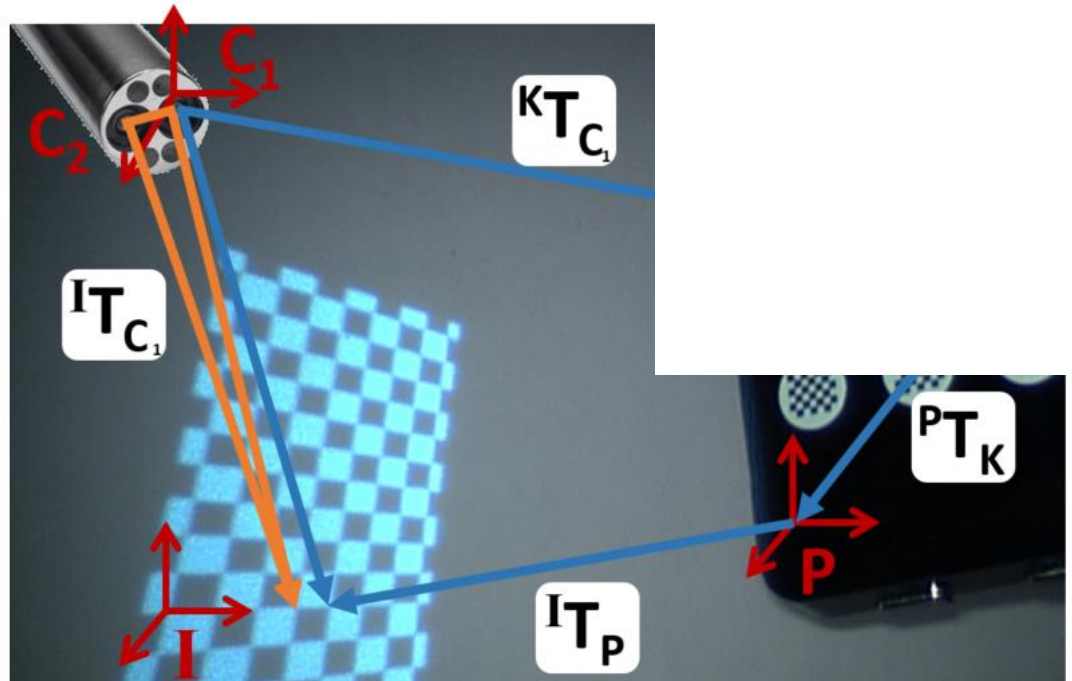
Pico Lantern - Pattern

- Projection pattern : checkerboard



Pico Lantern - Reconstruction

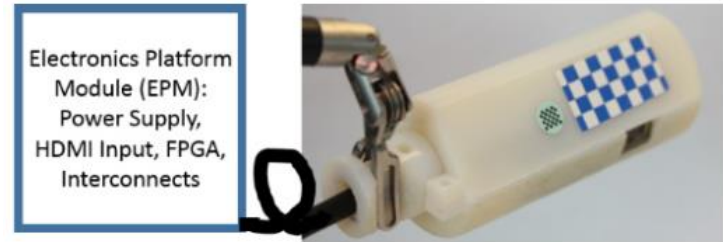
- **Method 1** Stereo Endoscope and Untracked Pico Lantern
- **Method 2** Mono endoscope and Tracked Pico Lantern



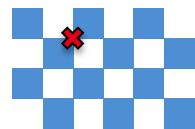
Pico Lantern - Reconstruction

- **Method 1** Stereo Endoscope and Untracked Pico Lantern
- **Method 2** Mono endoscope and Tracked Pico Lantern
- Wide baseline = better reconstruction accuracy...
- ... but Pico Lantern in FOV of the endoscope

Pico Lantern - Calibration



- Projector calibration
- Zang's method, as a camera in reverse



x , point in the projection pattern



? extrinsic projector parameters



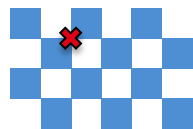
X , projected image point



Bouquet, J.-Y.: Visual Methods for Three-dimensional Modeling, (1999).

Pico Lantern - Calibration

- $X = R * x + T + \text{radial distortion}$
- optimization problem



x , point in the projection pattern



? extrinsic projector parameters



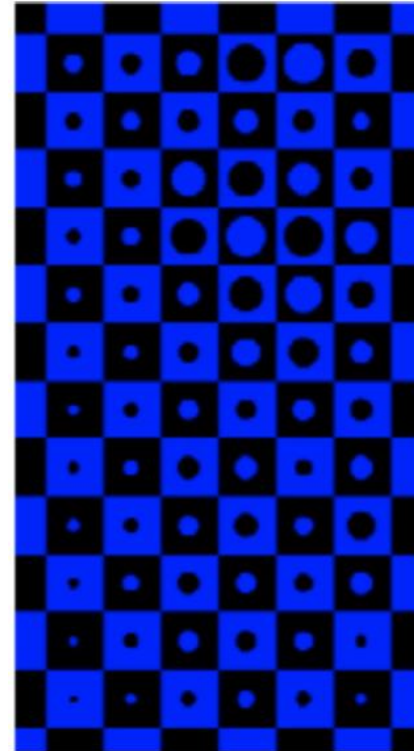
X , projected image point



Bouguet, J.-Y.: Visual Methods for Three-dimensional Modeling, (1999).

Pico Lantern – AR application

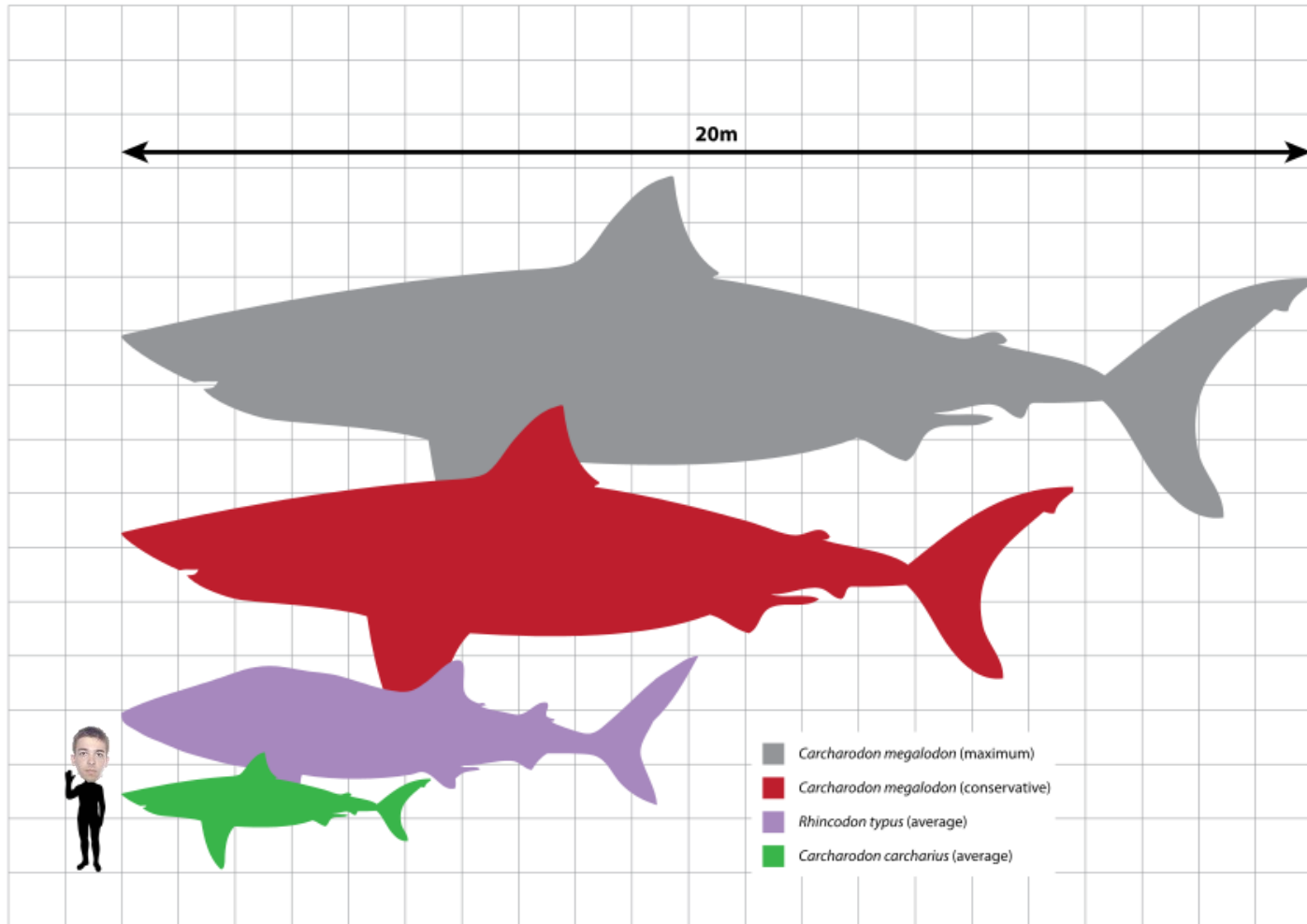
- Accurate, low-cost, fast
- in vivo measure of pulsatile motion of the carotid artery



Megalodon

- Pico Lantern = small lantern
- Megalodon = big tooth

Megalodon



Thank you