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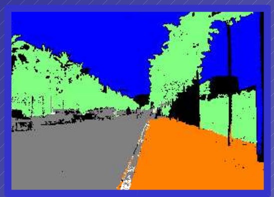
Computer Vision and Robotics

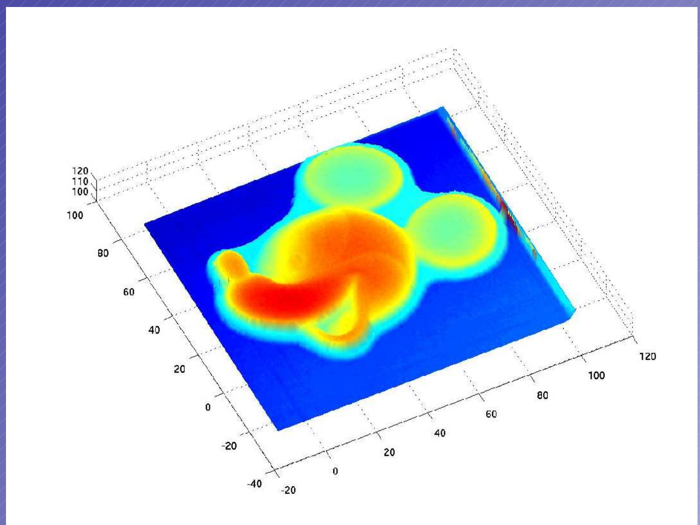
Institut d'Informàtica i Aplicacions
Universitat de Girona

Underwater Robotics



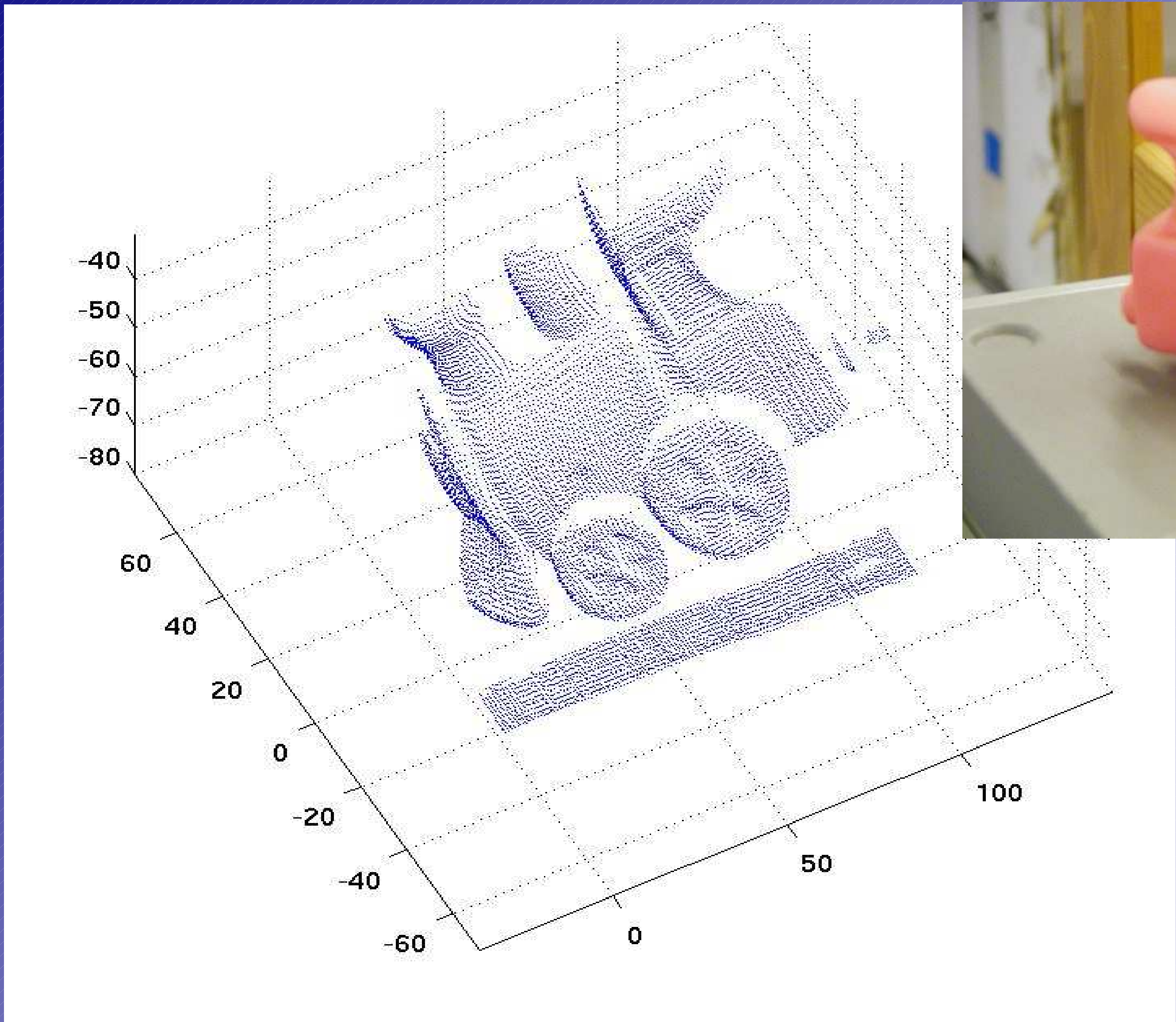
Computer Vision

Digital Hardware Architectures for real-time computer vision



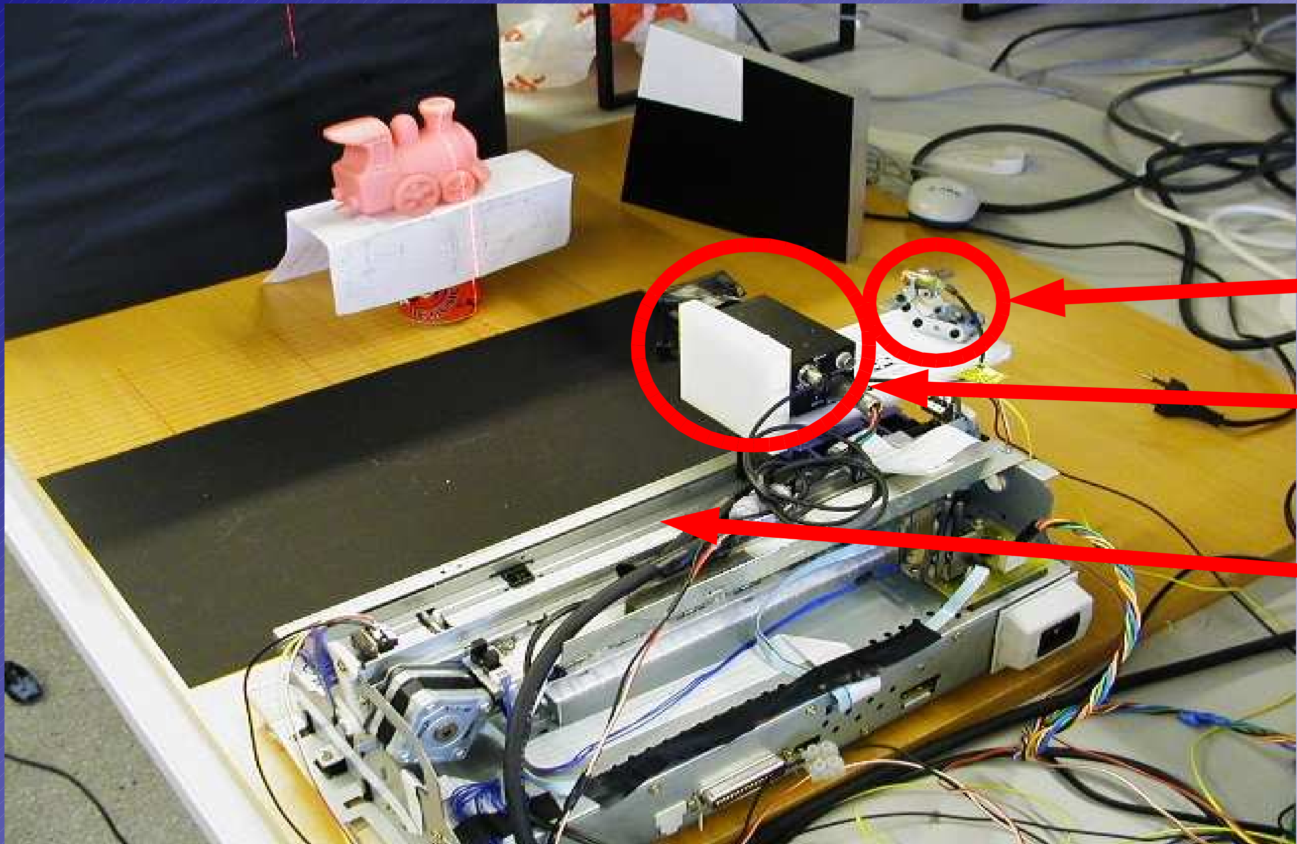
Three-dimensional vision

Three-dimensional vision



Three-dimensional vision

3D digitiser system



Laser Emitter

CCD camera

Motorised linear motion

Laser and camera scan the scene together. The linear motion is known to the system. The calibration and reconstruction by Projective Geometry principles (Chen & Kak, 1987).

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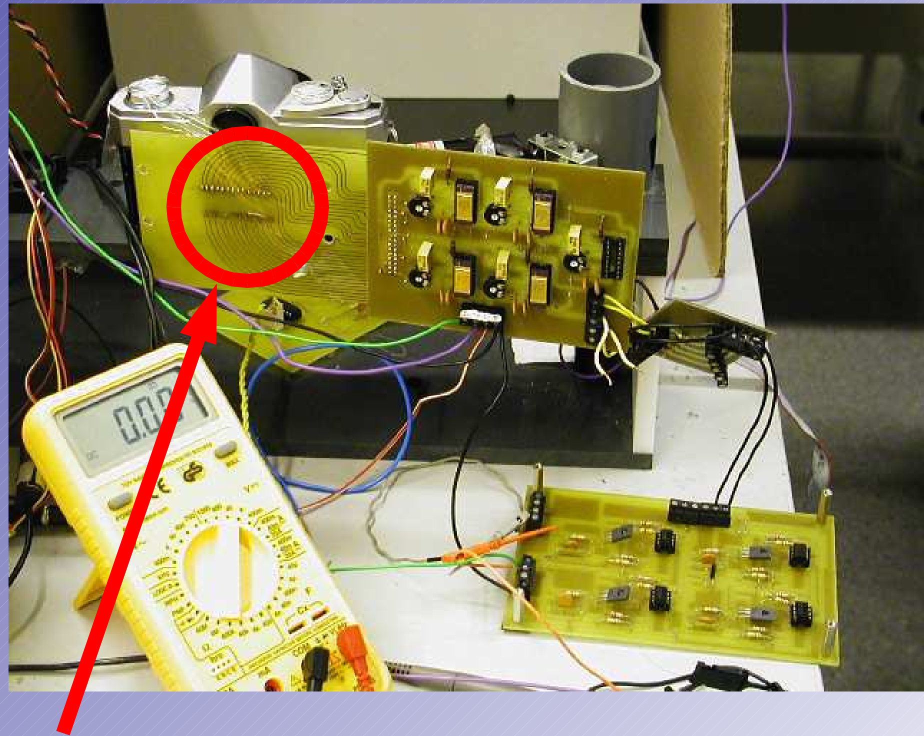
Three-dimensional vision

Real-time Range finder



5x5 photodiodes sensor. Hamamatsu S7585

Constant speed laser rotation. The time between a known reference optical switch and the impact of the laser image between 2 consecuteve PDs is measured (Yokoyama et. al. 1994).

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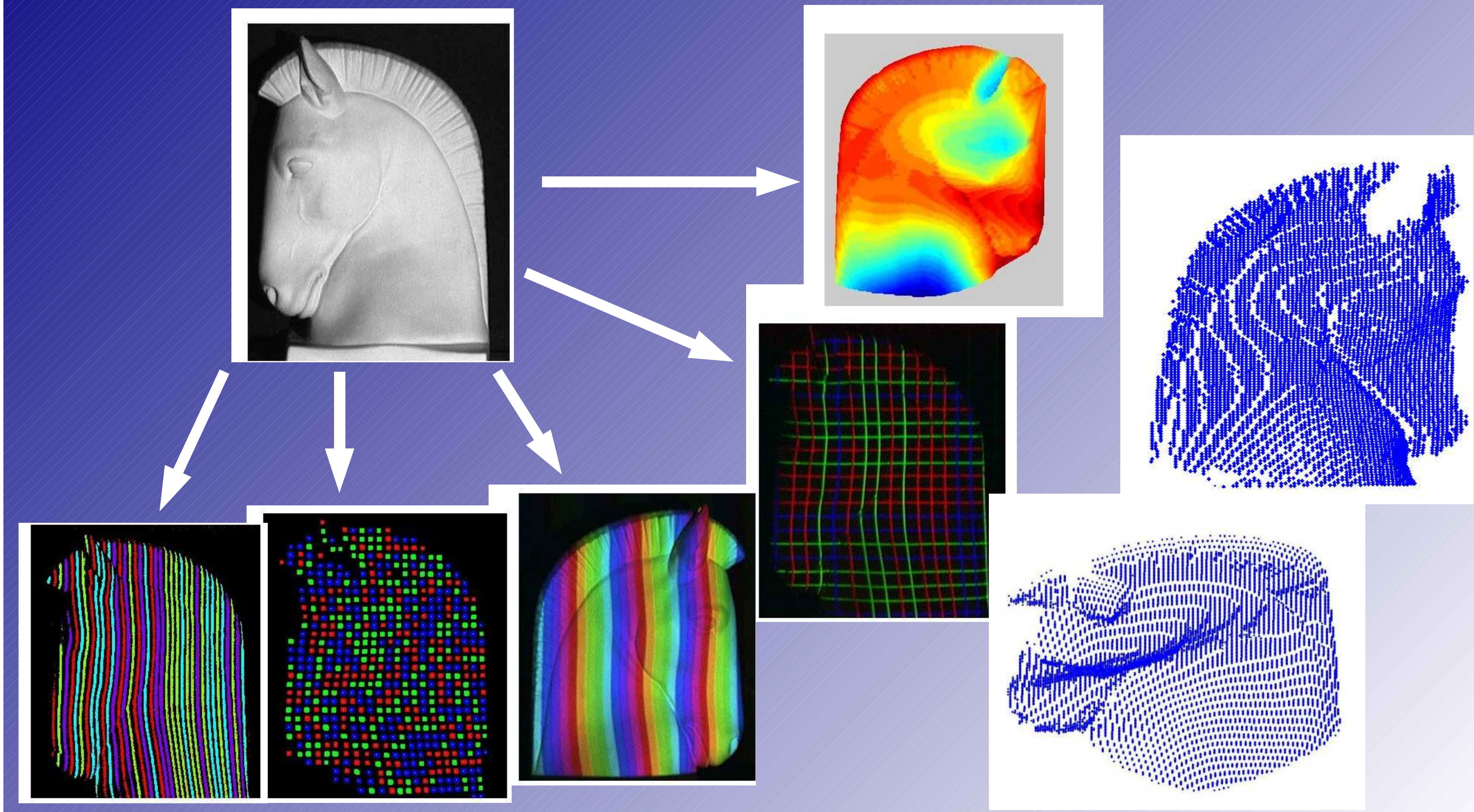
Three-dimensional vision

Coded structured light pattern projection



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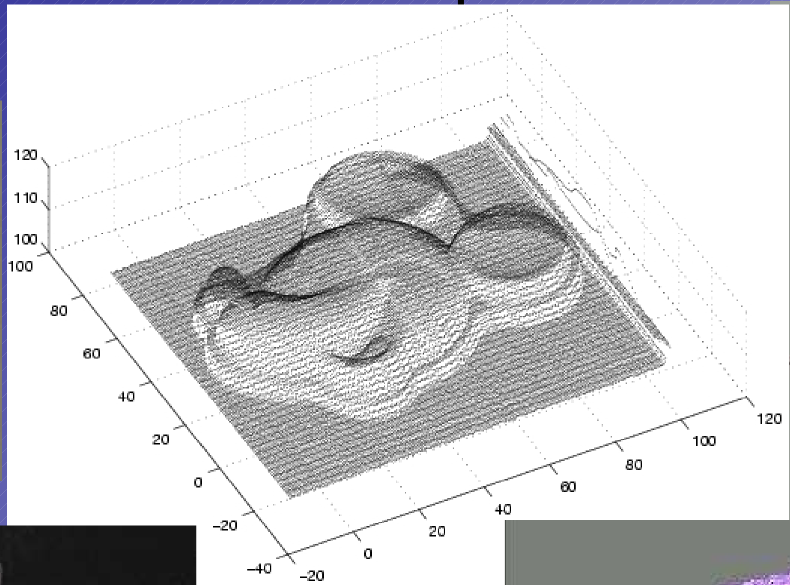
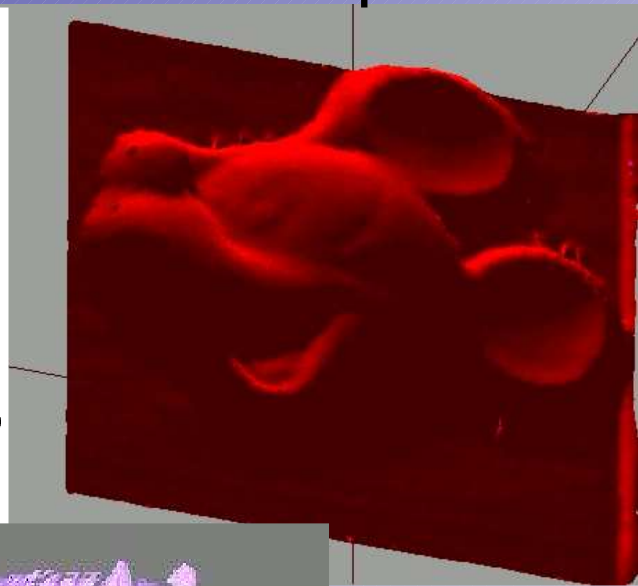
Three-dimensional vision

Cloud of points

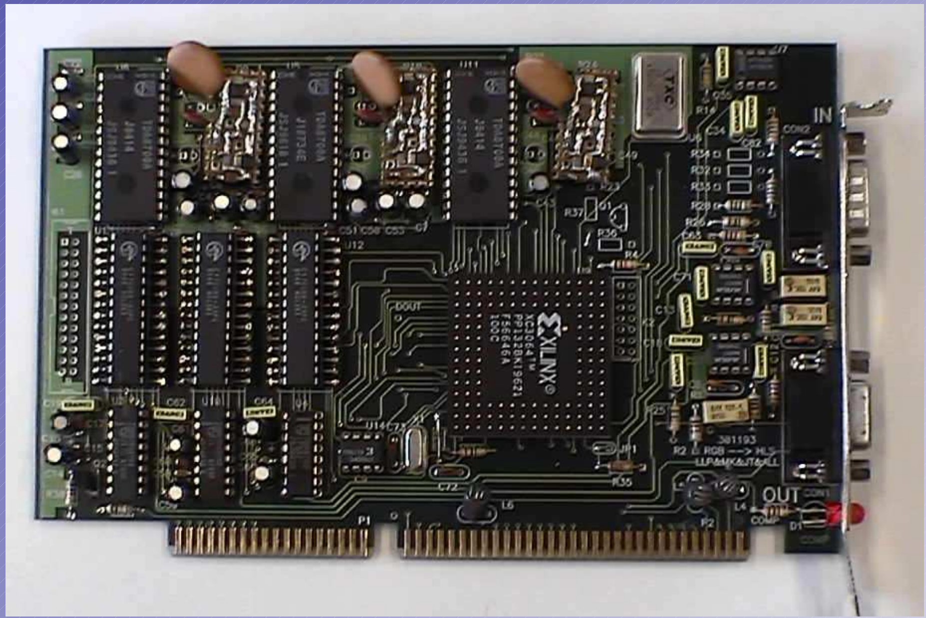
Surface interpolation





Computer Vision Architectures

RTC
1992. Video-rate segmentation of a scene by colour feature selection.



MAGTRAK
1998. Video-rate multiple object tracking by using colour feature segmentation.

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Computer Vision Architectures

MAGCL

2001. Modular distributed Architecture, allowing pipe-line and parallel interconnextino of different modules. Each module includes 1 FPGA and 1 DSP, which makes the most calculation-intensive tasks.

MIRAGE. 2002. 'Sandwich' type modular architecture. Additional boards may be added through 3 low-profile connectors.

Allows the operation with 2 CVBS/RGB cameras and digital cameras. Implementation of a real-time 3D architecture.

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A 30 Cloud-of-points per second three-dimensional digitiser:

THE 3-DIMENSIONAL CAMERA

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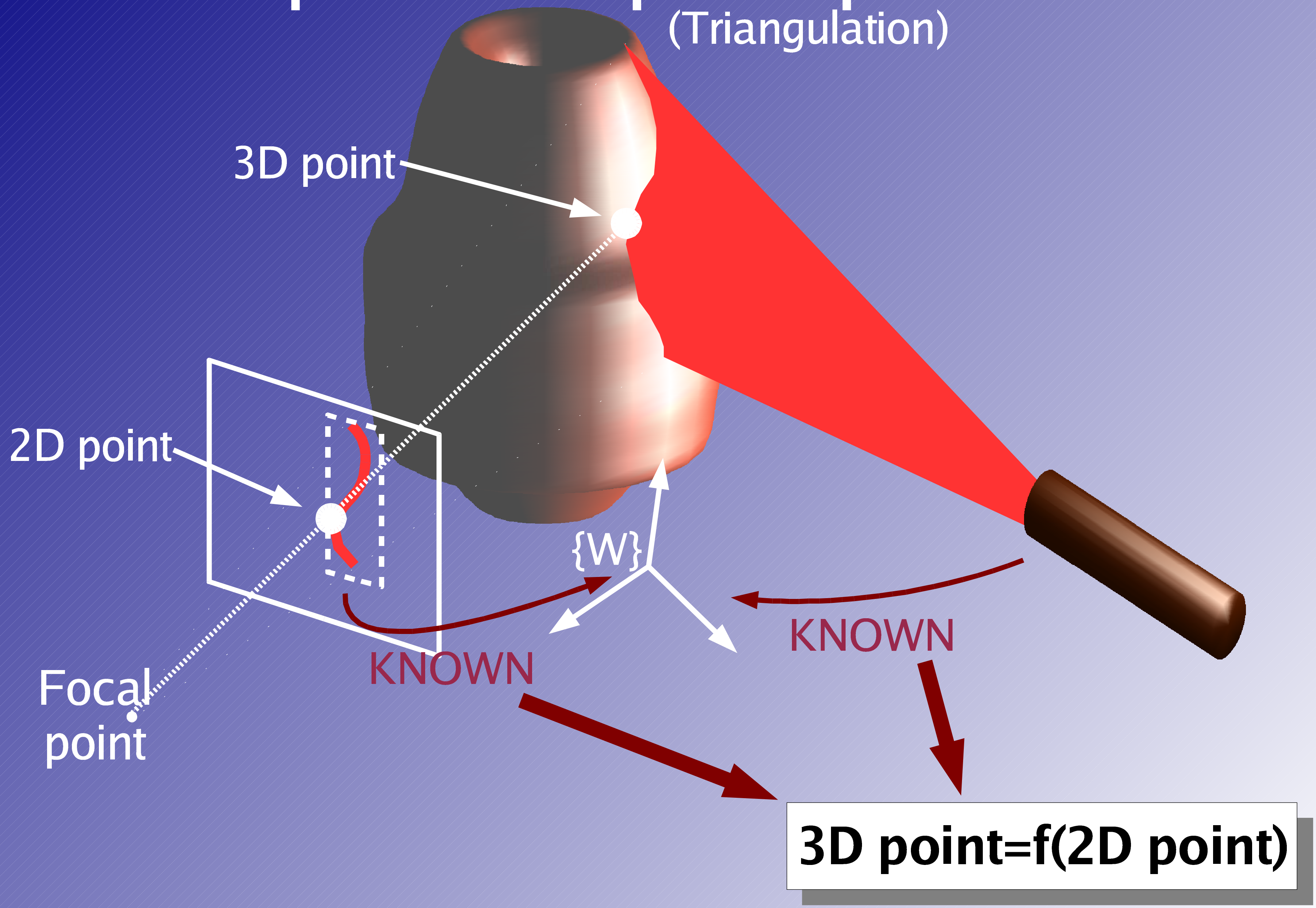
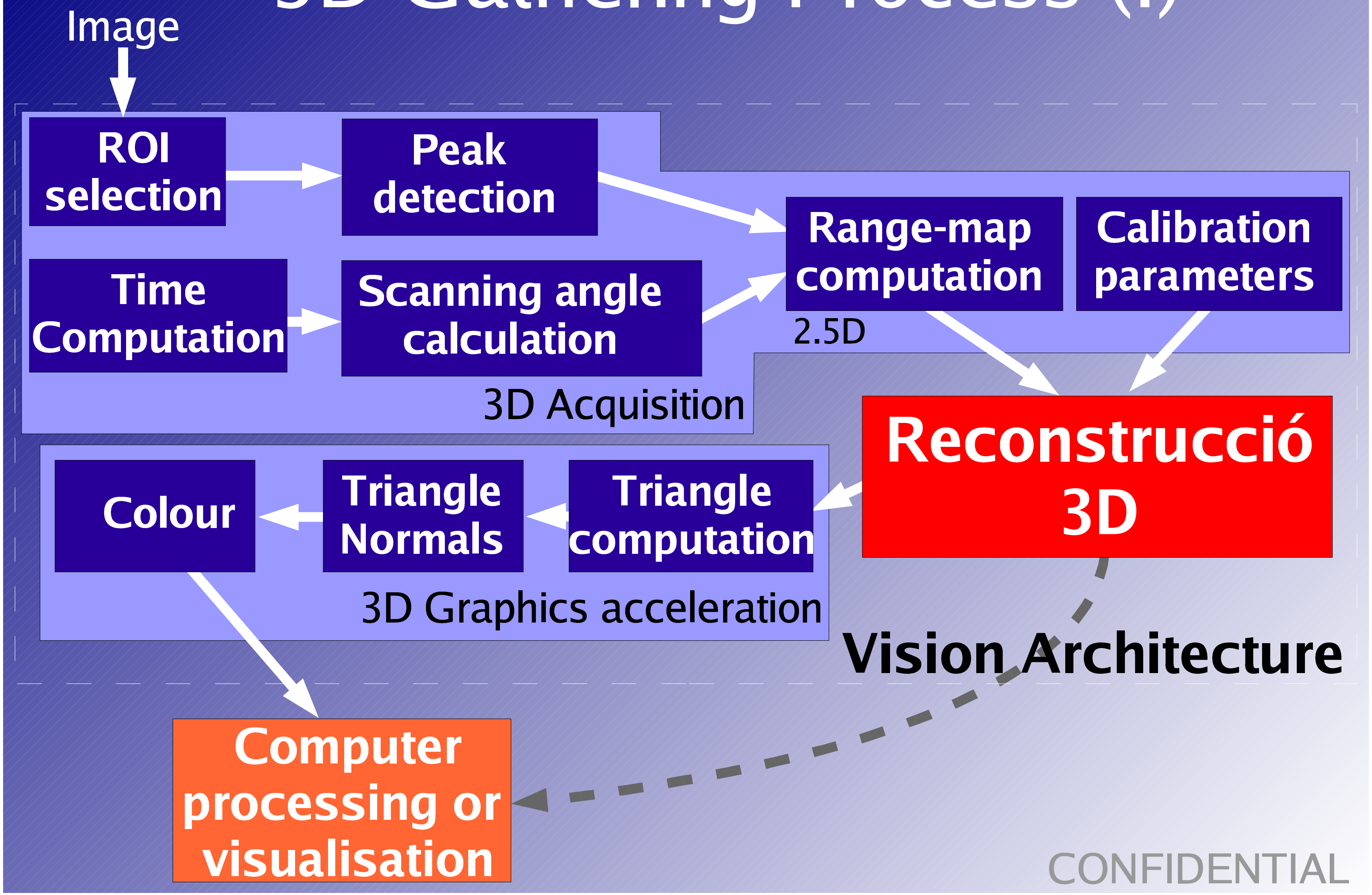
Operation principle

(Triangulation)



3D Gathering Process (I)



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3D Gathering Process (II)

3D Acquisition → ***High Speed High Accuracy***

3D Acceleration → ***Realistic Animation***

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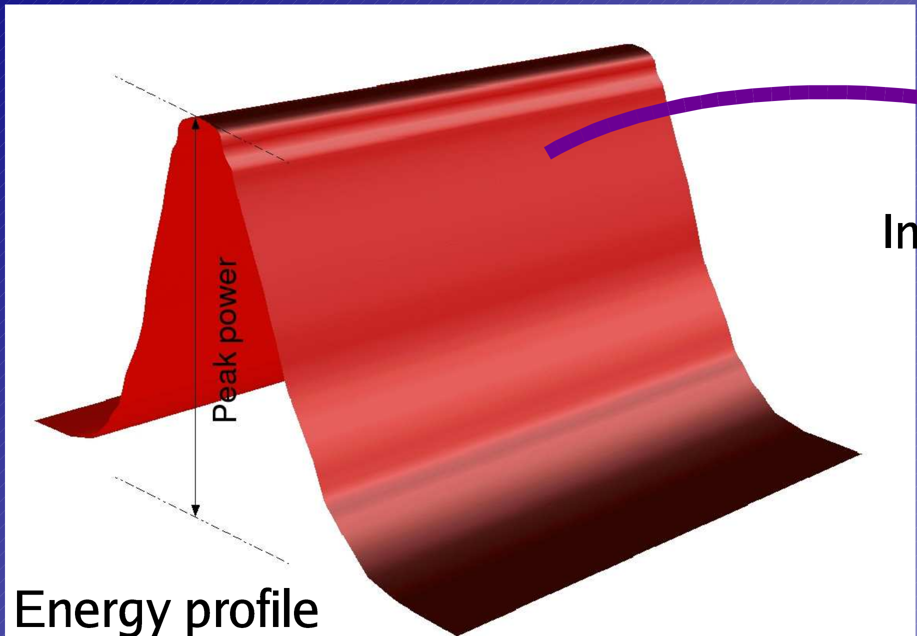
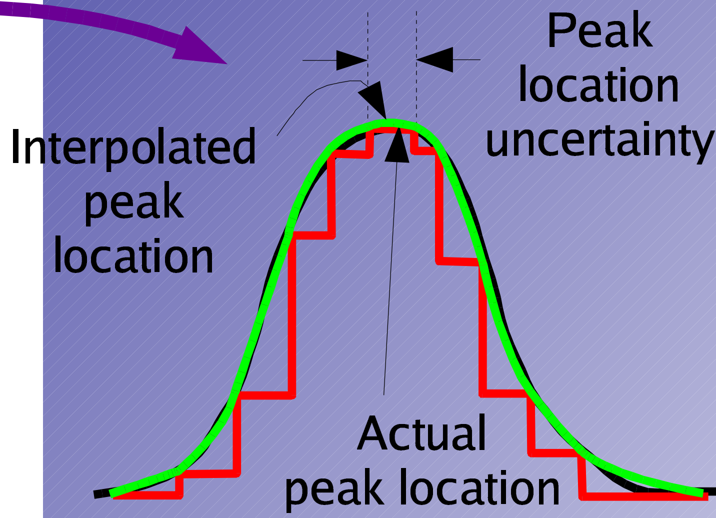
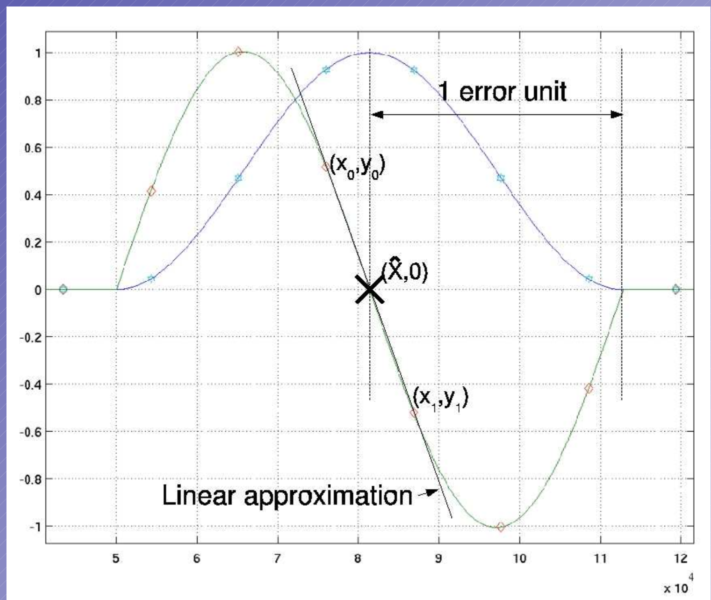
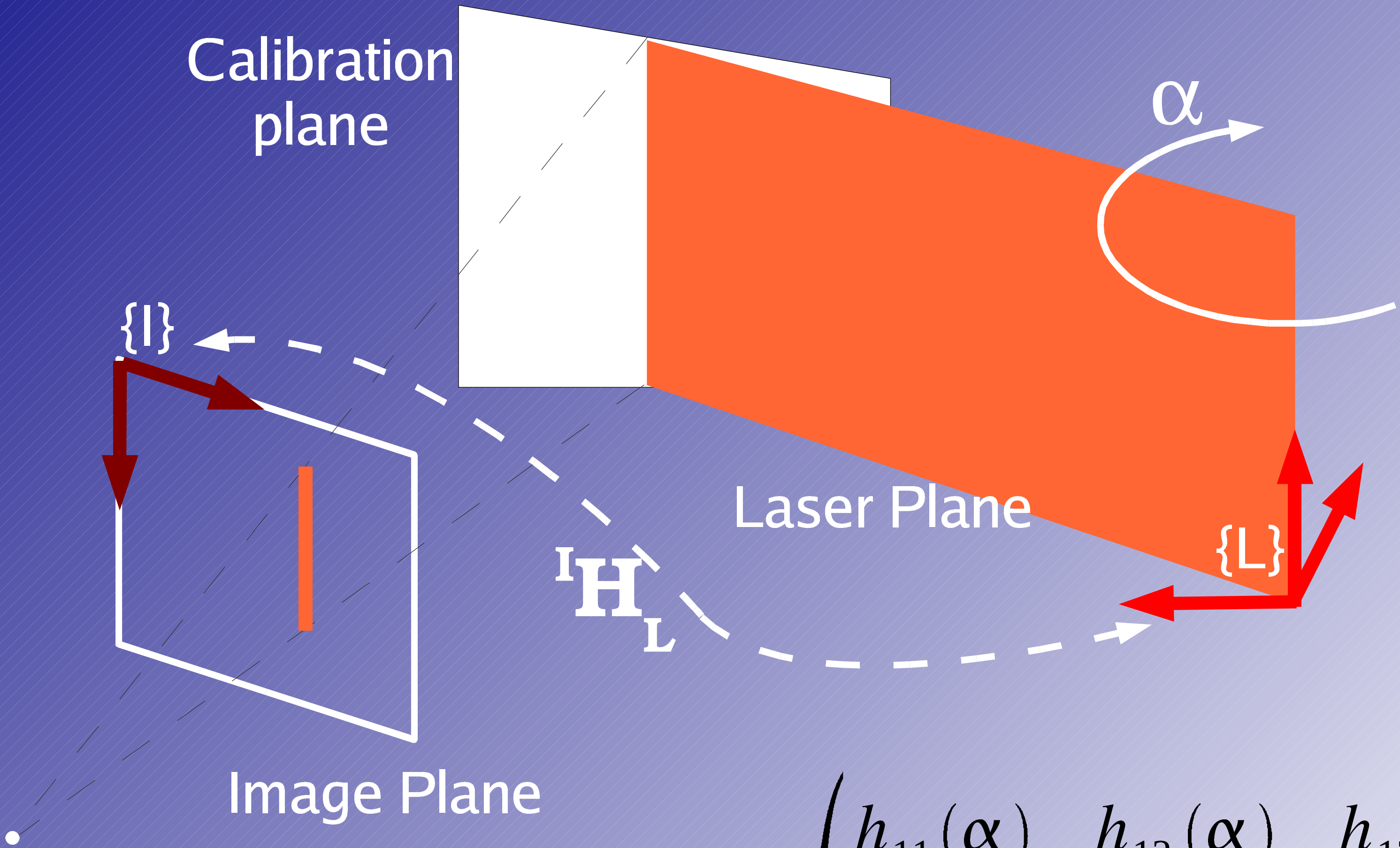
Accuracy (Peack detection)







Projective Calibration (I)



$$^{I}H_{L}(\alpha)=\begin{pmatrix} h_{11}(\alpha) & h_{12}(\alpha) & h_{13}(\alpha) \\ h_{21}(\alpha) & h_{22}(\alpha) & h_{23}(\alpha) \\ h_{31}(\alpha) & h_{32}(\alpha) & 1 \end{pmatrix}$$

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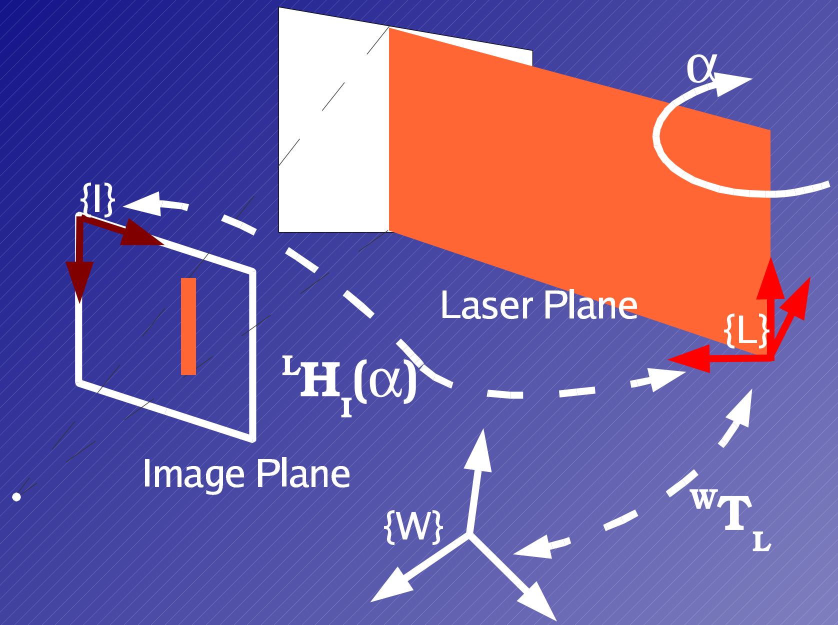
Projective Calibration (II)

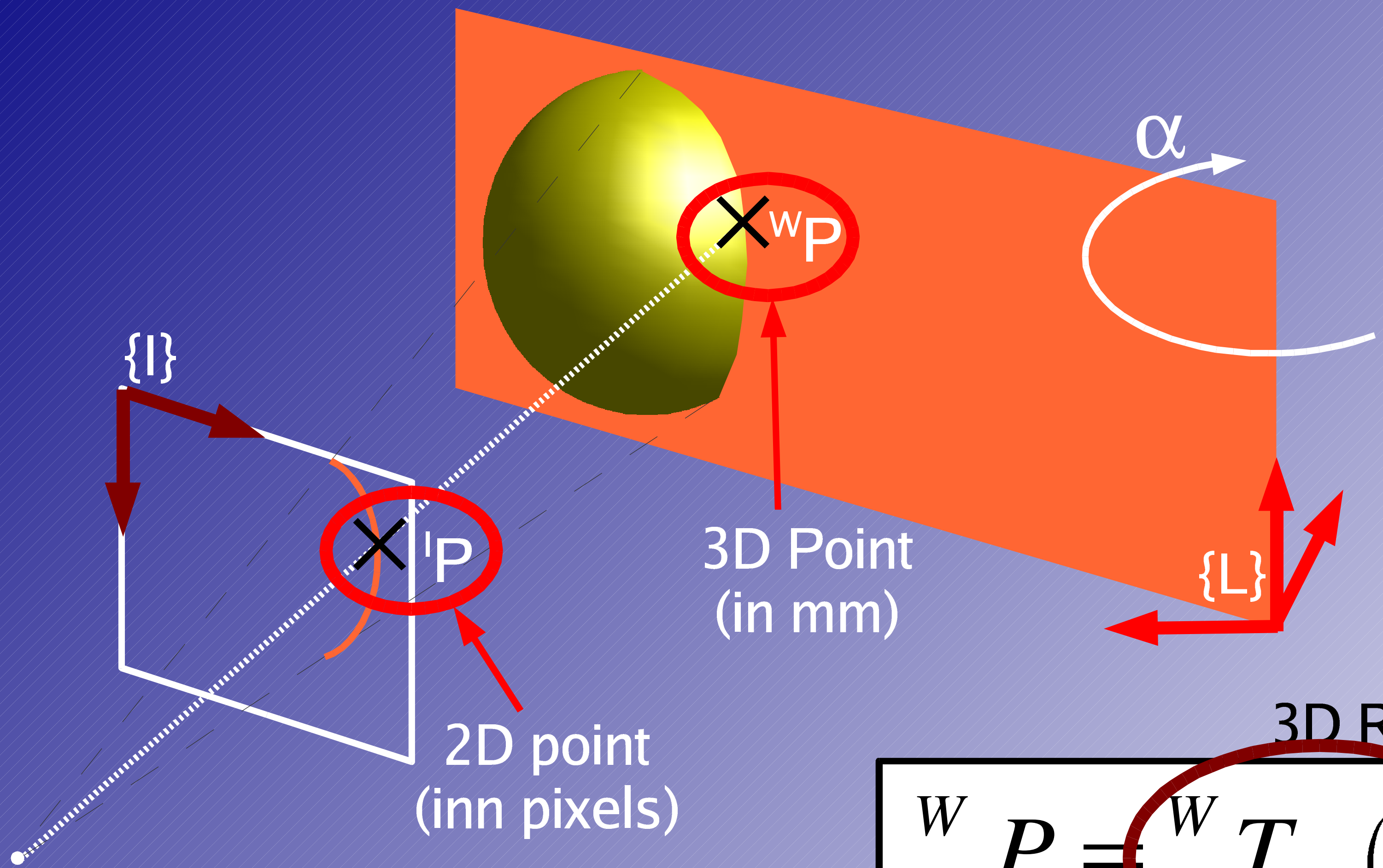


$$^{L}H_{I}(\alpha)=\begin{pmatrix} h_{11}(\alpha) & h_{12}(\alpha) & h_{13}(\alpha) \\ h_{21}(\alpha) & h_{22}(\alpha) & h_{23}(\alpha) \\ h_{31}(\alpha) & h_{32}(\alpha) & 1 \end{pmatrix}$$

$$^{W}T_{L}=\begin{pmatrix} t_{11} & t_{12} & t_{13} & t_{14} \\ t_{21} & t_{22} & t_{23} & t_{24} \\ t_{31} & t_{32} & t_{33} & 1 \end{pmatrix}$$

$$^{W}T_{I}(\alpha)={}^{W}T_{L}\cdot {}^{L}H_{I}(\alpha)=\begin{pmatrix} d_{11}(\alpha) & d_{12}(\alpha) & d_{13}(\alpha) \\ d_{21}(\alpha) & d_{22}(\alpha) & d_{23}(\alpha) \\ d_{31}(\alpha) & d_{32}(\alpha) & d_{33}(\alpha) \\ d_{41}(\alpha) & d_{42}(\alpha) & 1 \end{pmatrix}$$

Projective Calibration (III)



3D Reconstruction

$$^{W}P = {}^{W}T_{I}(\alpha) \cdot {}^{I}P$$

Known by calibration

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Projective Calibration (IV)

3D Reconstruction

$$ {}^{W}P = {}^{W}T_{I}(\alpha) \cdot {}^{I}P $$

Pros

- Easy calibration process
- Reconstruction by matrix multiplication
- α is the only dependence
- Noise robustness
- No precision mechanics needed for camera-laser alignment

Very Fast 3D acquisition

High accuracy

Low cost mechanics

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THE 3-DIMENSIONAL CAMERA

as a CMOS design approach

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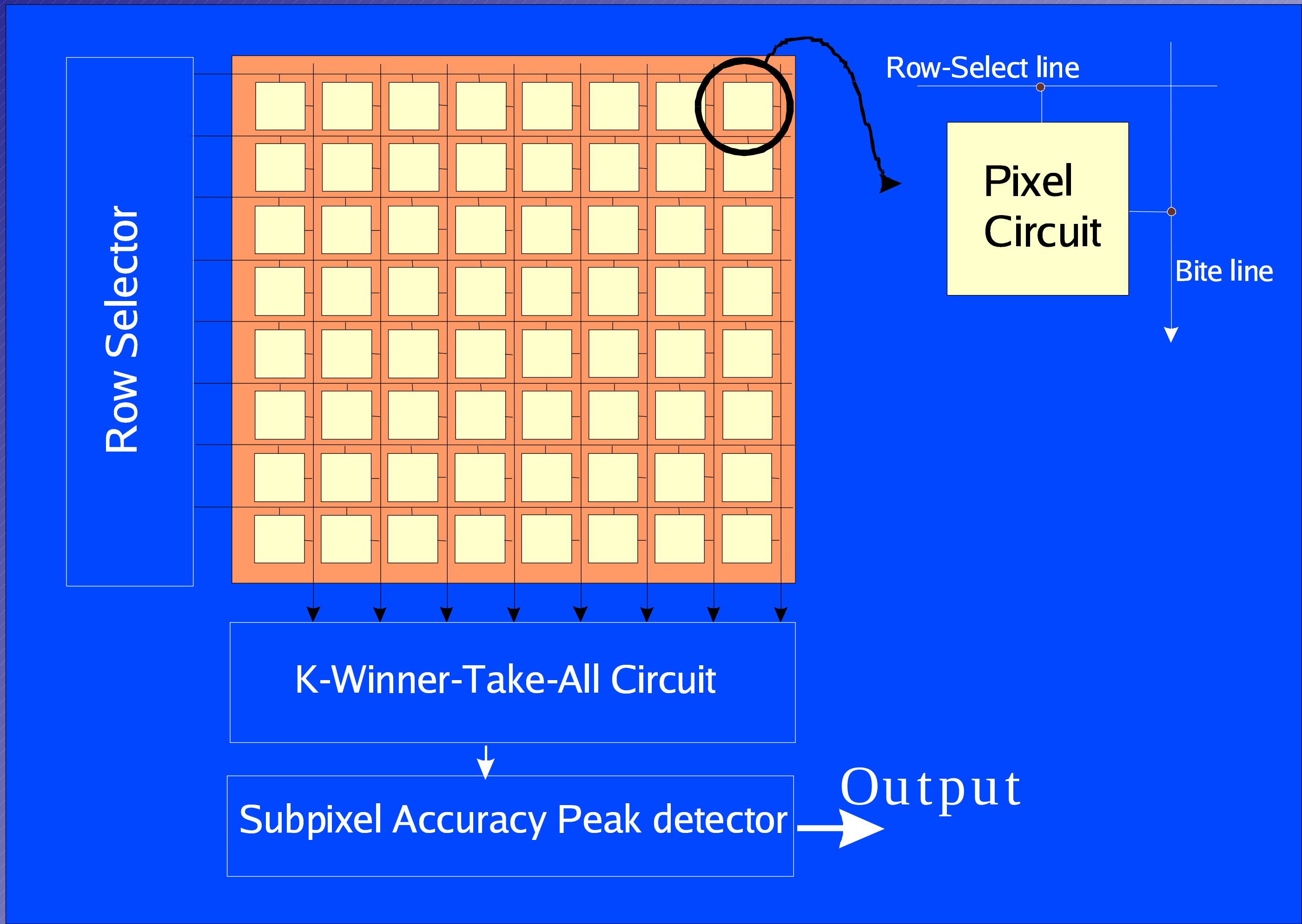
Tree-dimensional Vision (3D camera)

CMOS Image Sensor Floorplan



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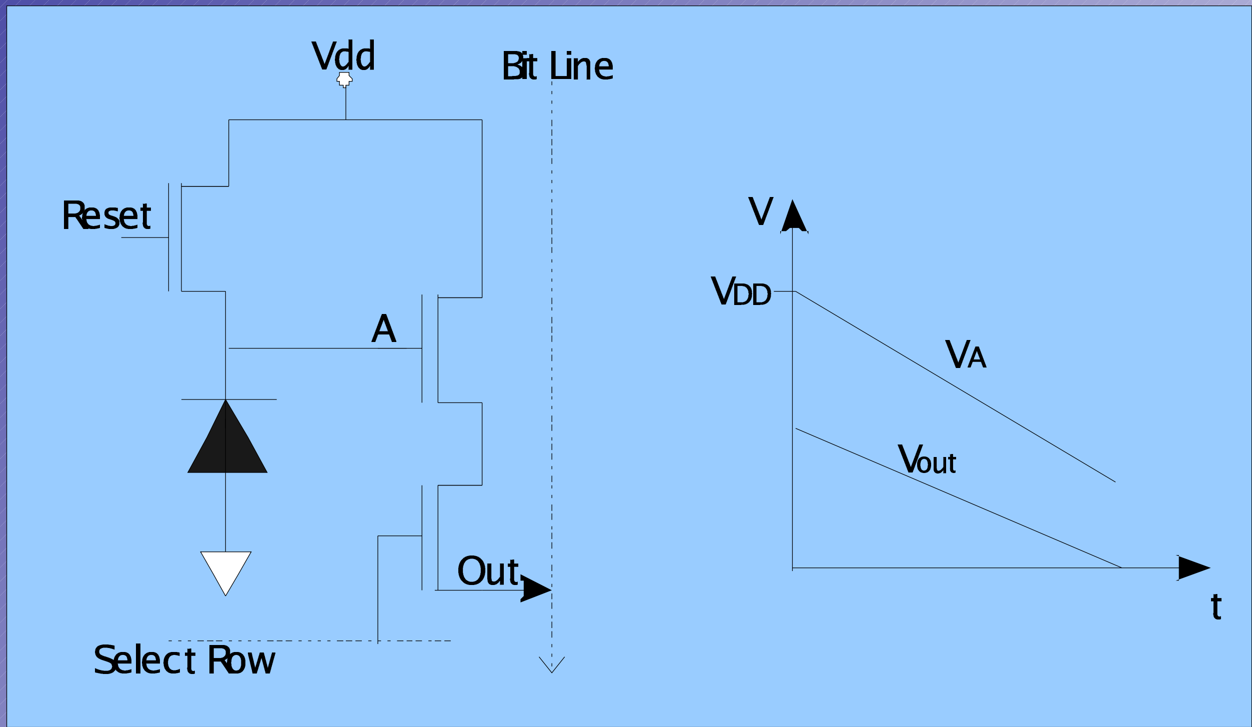
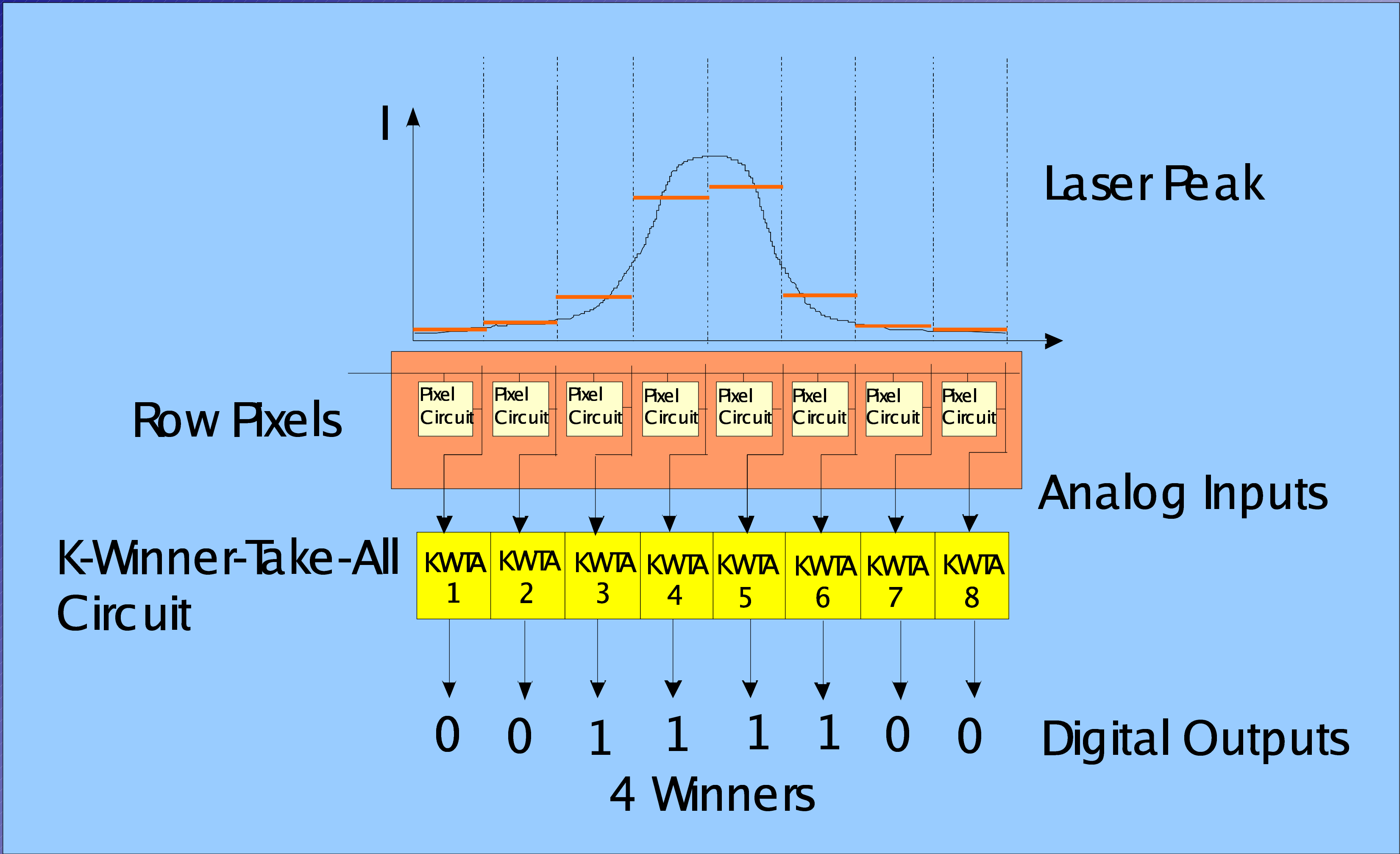
Pixel Circuit

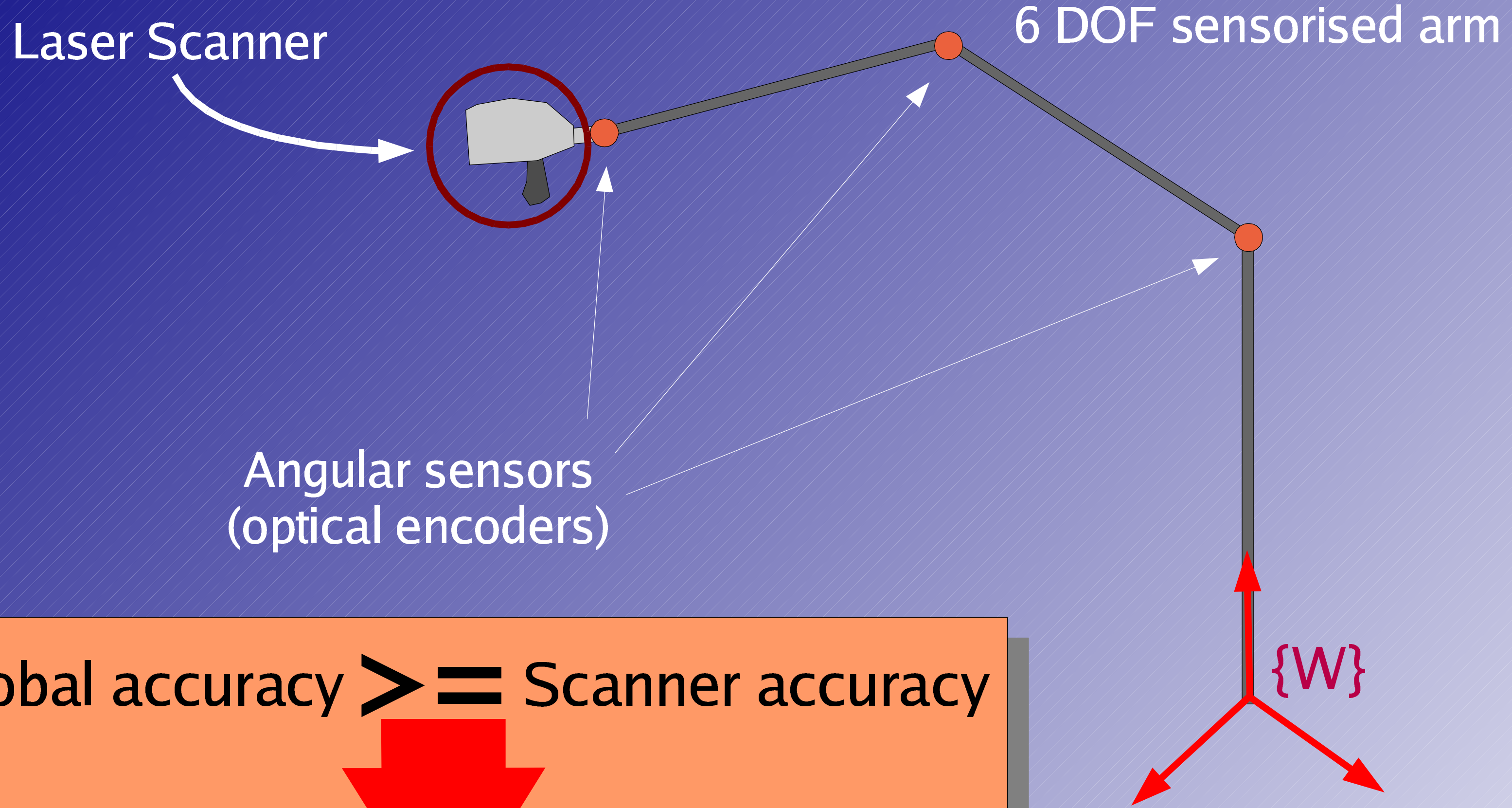
- APS(Active Pixel Sensor)
- Example:



K-Winner-Take-All Circuit



Global Reconstruction (I)



Global accuracy >= Scanner accuracy

High resolution optical encoders

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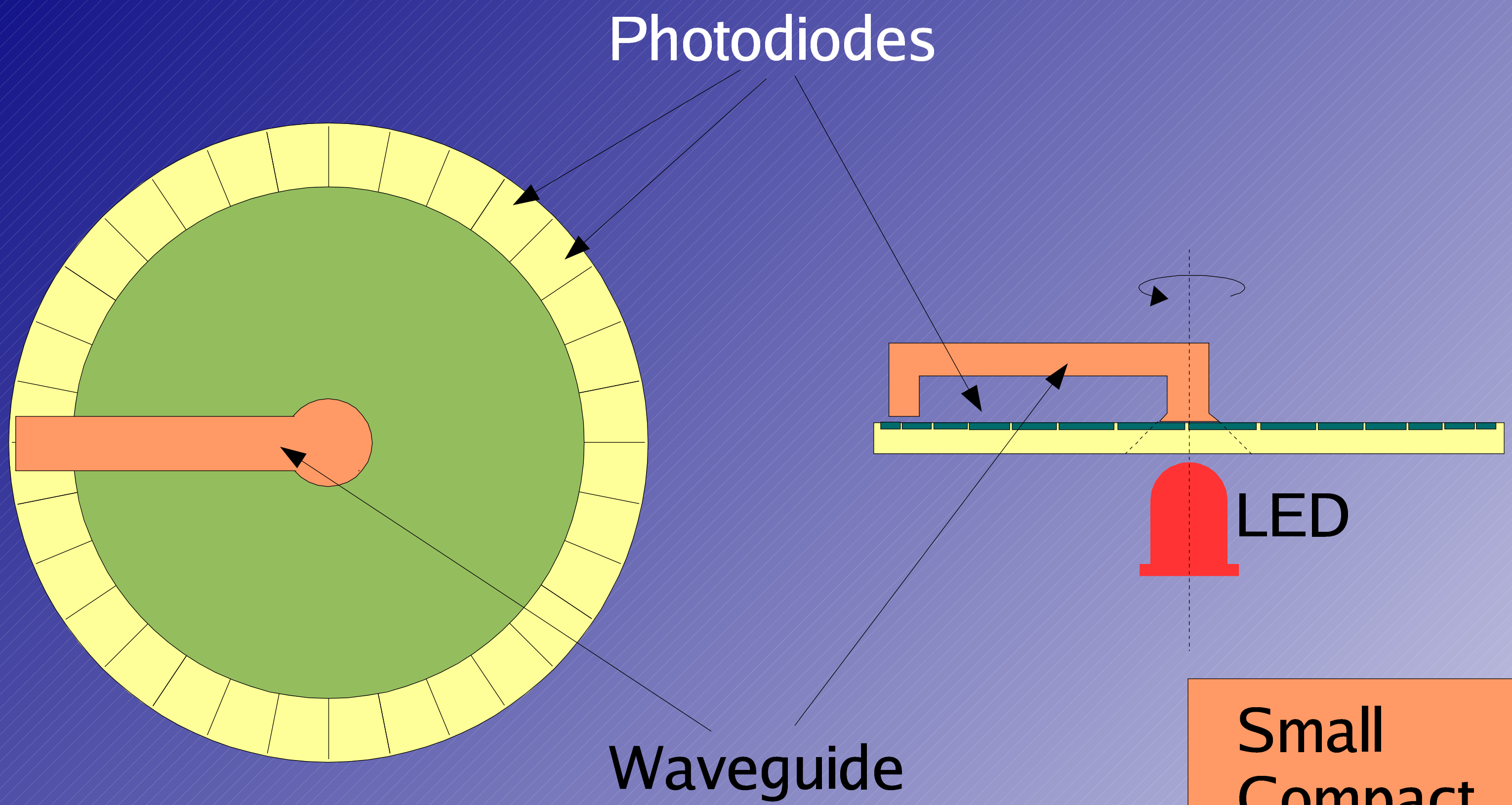
Global Reconstruction (II)



Silicon angular sensor

- Small
- Compact
- Rough
- Robust
- High Resolution
- Cheap

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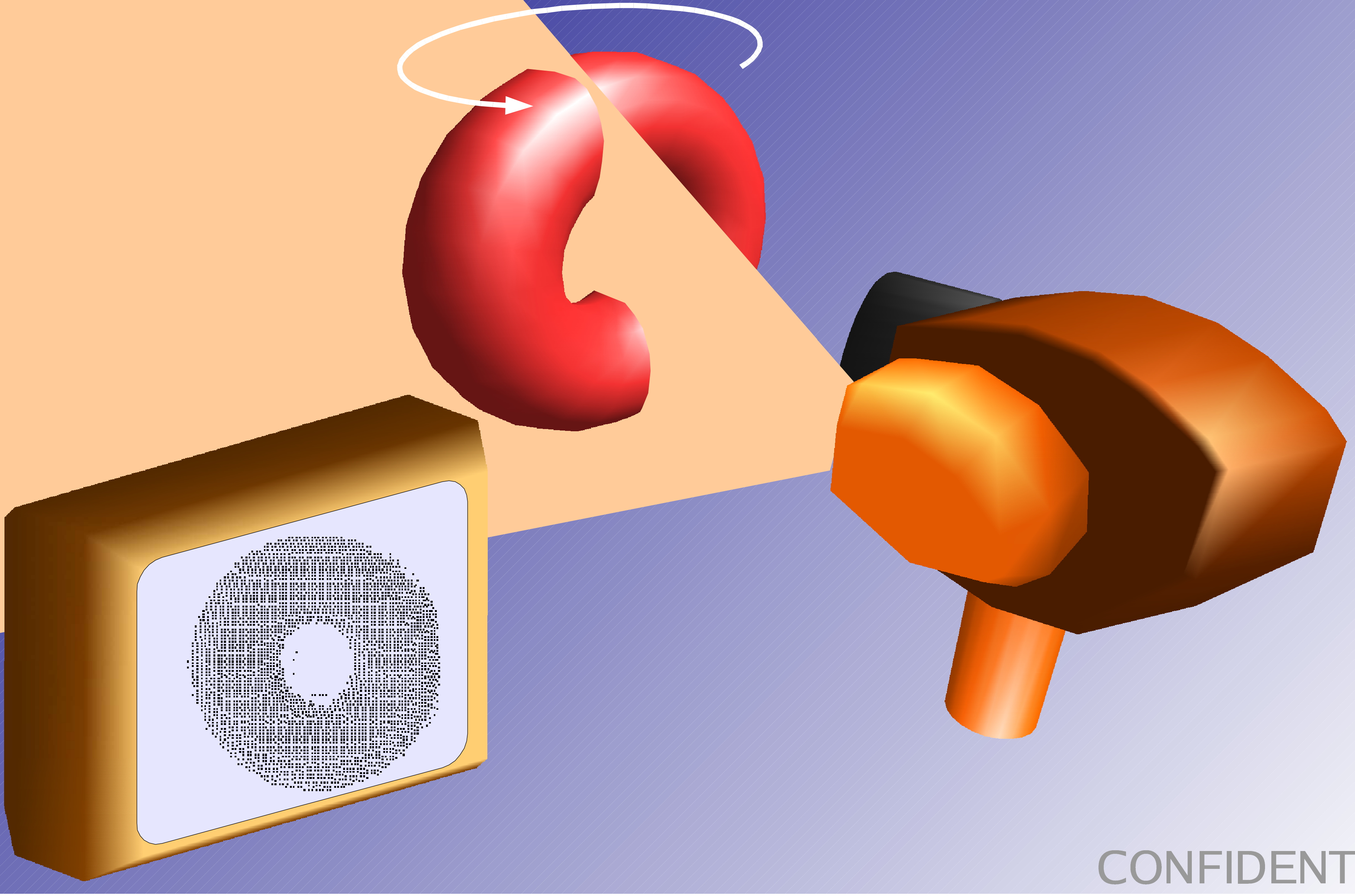
ShapeSens: SPIN-OFF proposal



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ShapeSens

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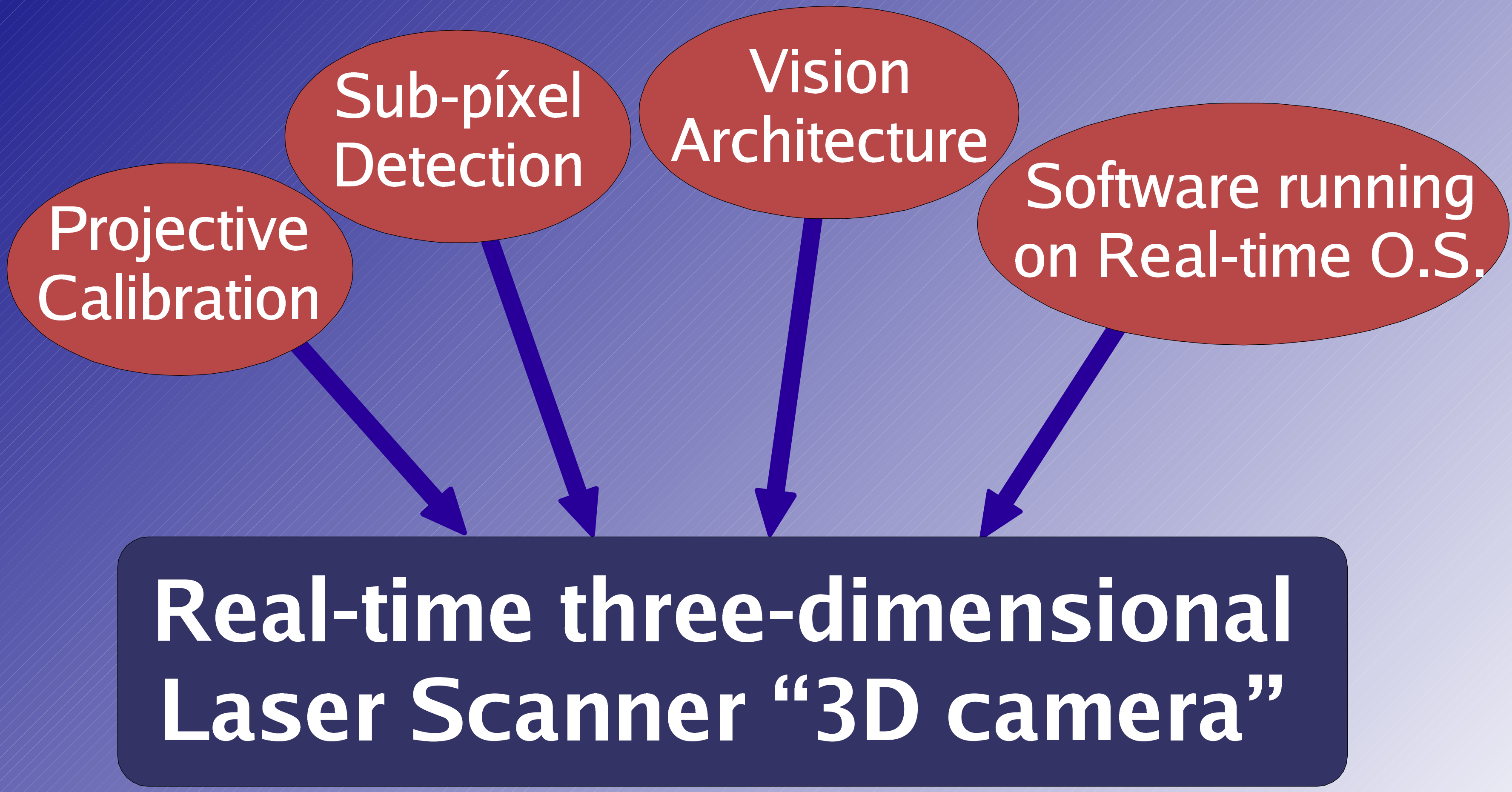
Product Idea



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Aplications

Industry
- •Automotive
- •Aerial
- •Space
- •Quality assurance
- •Inverse engineering
- •Rapid prototyping
- •3D modelling
- •Automatic machine guidance

Medicine
- •Assisted surgery
- •Dermatology
- •Stetics

Robotics
- •3D envirionment Perception
- •3D mapping
- •Navigation

Cinema
- •Virtual scenery creation
- •Realistic 3D graphic creation

Virtual Reality
- •Virtual worlds from Real worlds
- •Augmented Reality

Archaeology
- •Digitisation of whole ruins for realistic virtual visits
- •Ancient craftsman parts 3D reconstruction

Art
- •Artwork retorting

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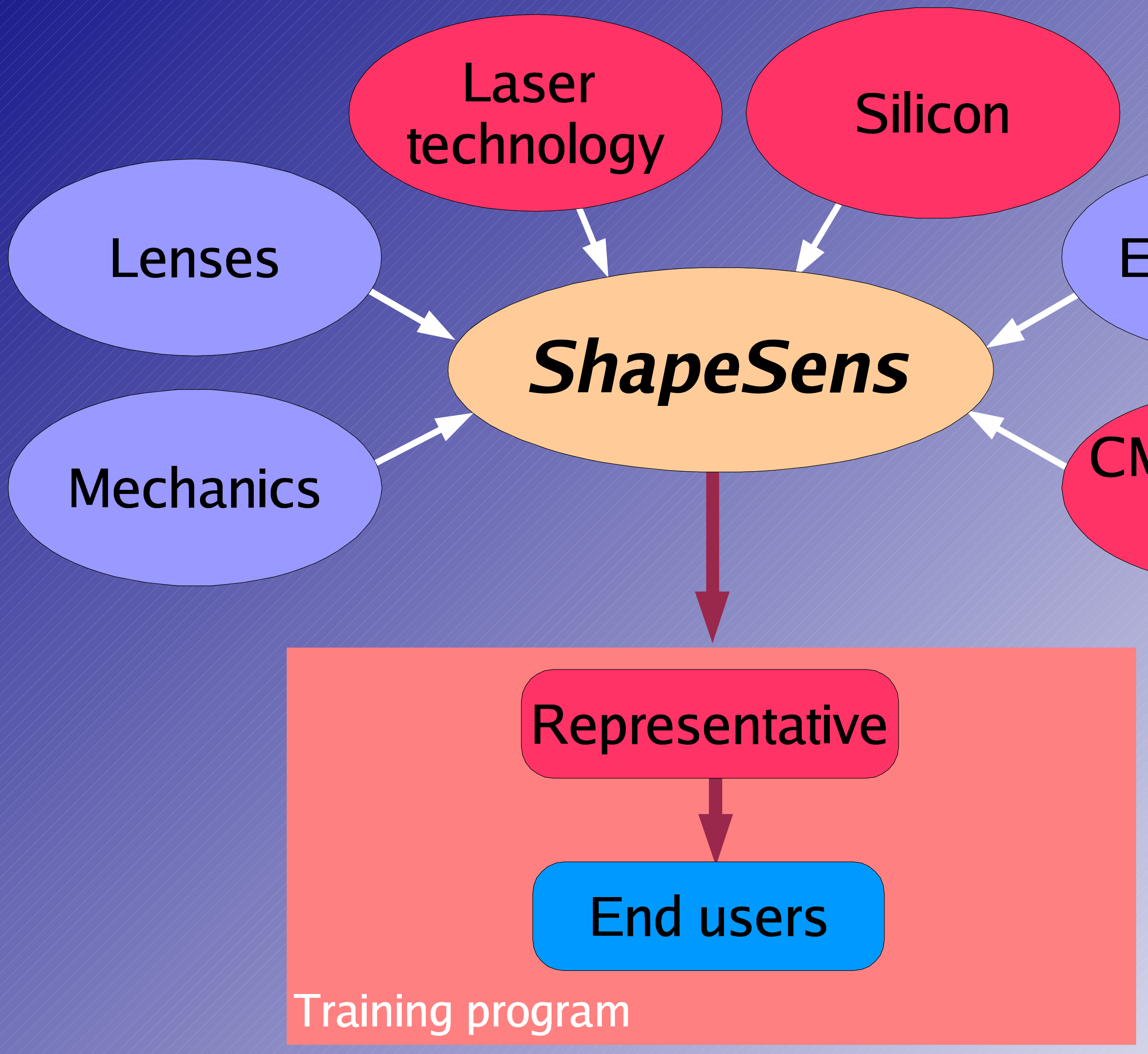
Business plan



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Our Competitors

Manufacturer	Model	Accuracy(um)	Resolution	Speed(points/s)	3D data type
INO		250	256 points/perfil	230400	Profile
MINOLTA	Vivid 910	40	307000 points/frame	122800	Cloud of points
3SHAPE	H-100	10 a 100	100 a 700 um	3500	Profile
KREON3D		5		30000	Profile
AXILA	G-SCAN			16000	Profile
HYMARC		25		10000	Profile
IVP	M50		1536 Z values	15360000	Profile
ORIGIN	RS400	13	500 xy points		Cloud of points
PERCEPTRON	ScanWorks	50	420 um	23040	
POLHEMUS	FastScan Cobra	1000	500 um		Profile
SURPHASER	Model 25	25		200000	Cloud of points
STEINBICHLER	Comet T-Scan	30	150 um		Profile

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Performance of Our product

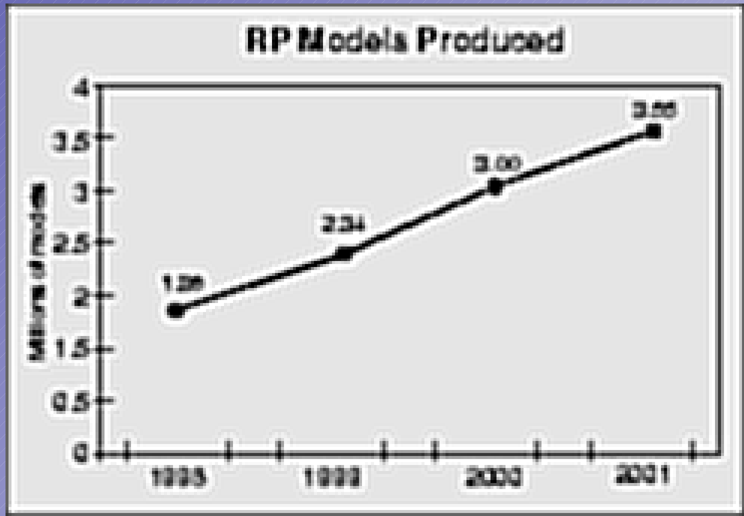
Accuracy:	**40 um**
Resolution:	**98 um**
Speed*:	**20000000 points/s**
3D data type:	**Cloud of points / Profile**

* 30 clouds of points per second

Expectations

Rapid Prototyping: An example

RP users worldwide produced 3.55 million models and prototype parts in 2001.
This is a growth of 18.3% from the 3 million produced in 2000*.



Almost any 3D industry (Hw or Sw) has experienced a significant growth, despite the decline in overall industry growth.

* Source: Wohlers Report 2002