



## 4<sup>th</sup> Tensilica Day

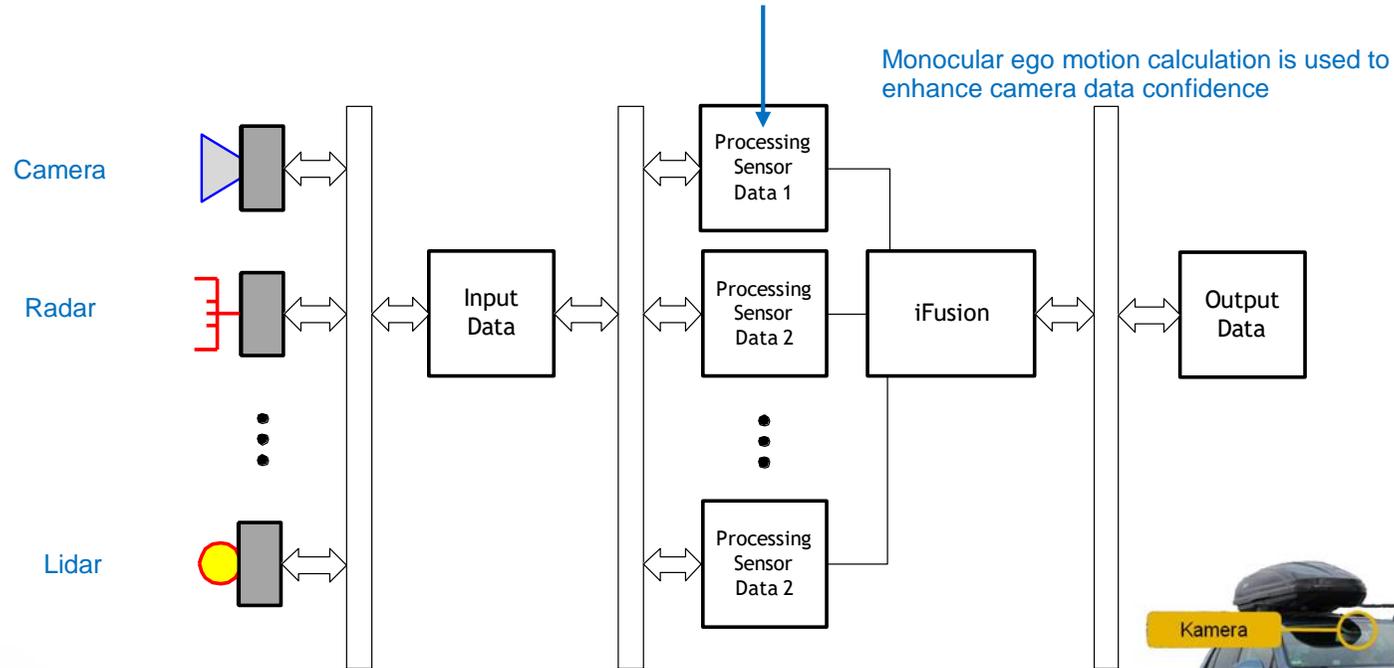
23<sup>st</sup> and 24<sup>nd</sup> of September 2019

## Ego Motion Estimation

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# Usage of Ego Motion Estimation: iFUSE Project

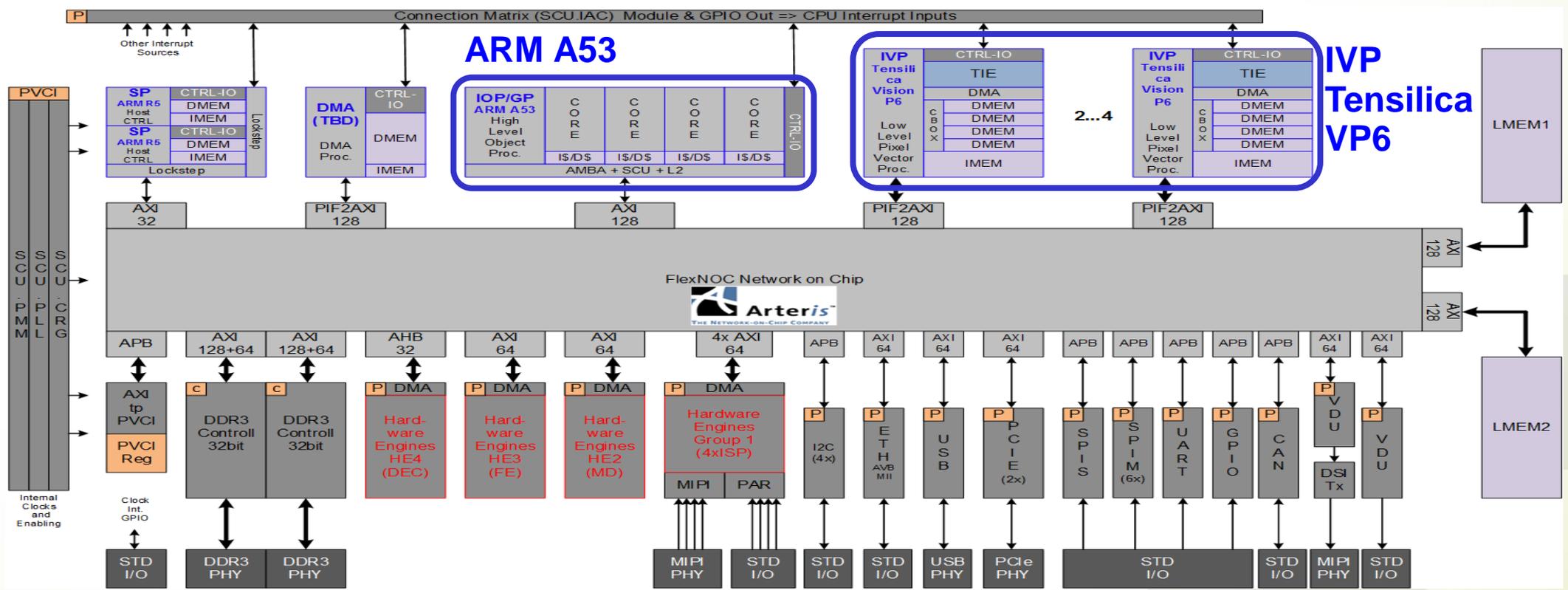
Video data pre processing: Stereo depth maps, ..., **monocular Ego-Motion calculation**, ...



iFUSE Project Goal  
Autonomous driving through a test crossroad.

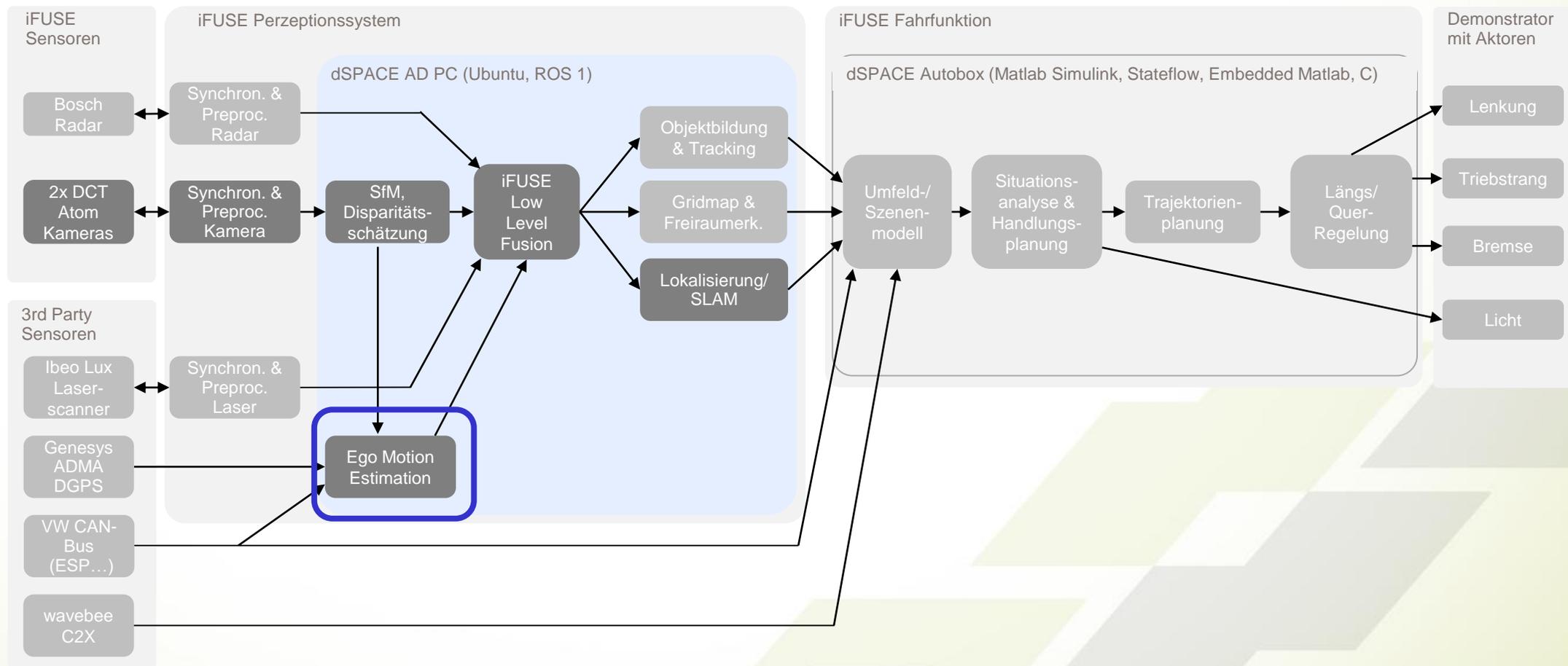


# SDIP SoC (Things2Do Project)



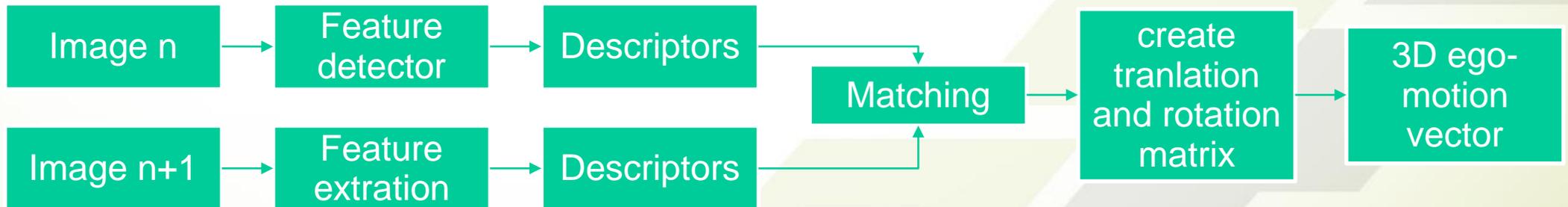


# iFUSE Hardware Block-Diagram



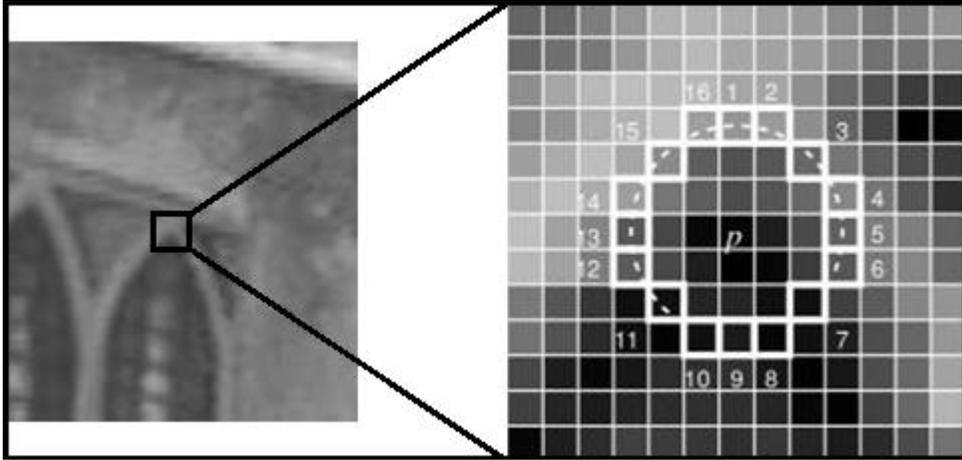
## Ego Motion Estimation

- Reference Algorithm
  - Evaluation of various egomotion algorithms
  - ORB (Oriented FAST and Rotated BRIEF) feature extraction
    - Optical flow added to enhance feature extraction
    - Hierarchical decomposition of frames for scaling invariance of features
  - Matching of extracted features in secutive frames
  - Ego motion vector calculation using „feature matching vectors“
    - Essential Matrix and create translation and rotation matrix



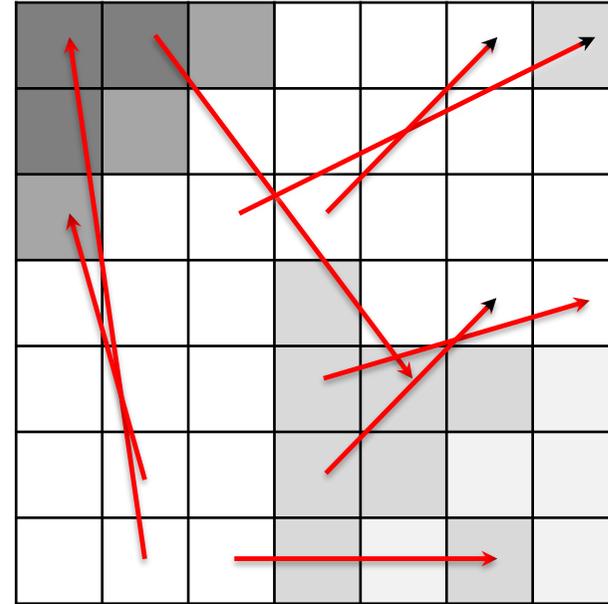
# Ego Motion Estimation

FAST (Features from Accelerated Segment Test)



- Corner detector
- Faster than Sift and Surf
- Compare  $p$  with 16 pixel around
  - If more than 12 grayscale values brighter  $\rightarrow$  corner
  - If more than 12 grayscale values darker  $\rightarrow$  corner

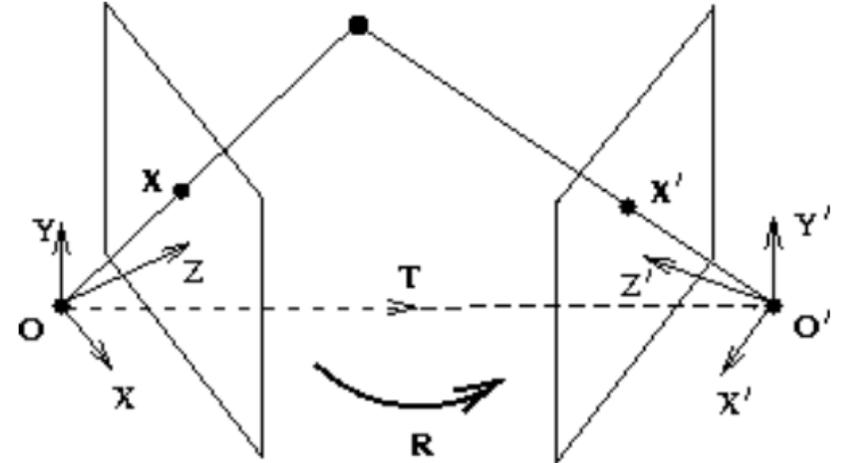
BRIEF (Binary Robust Independent Elementary Features)



Brief 8b = 10010100

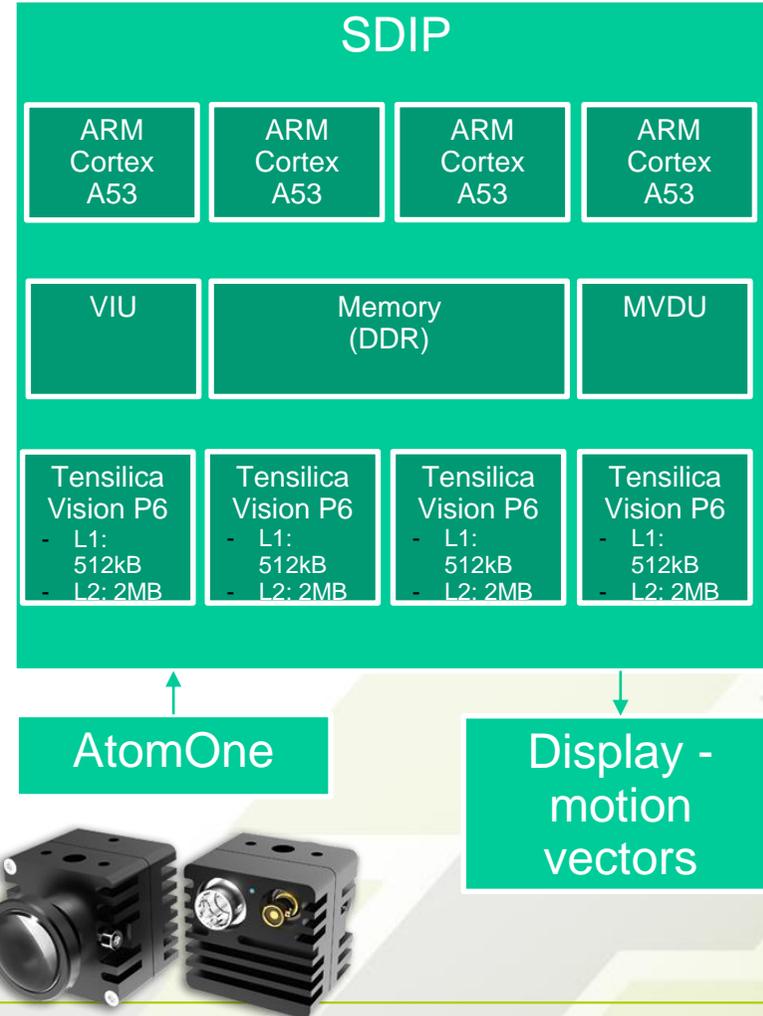
## Ego motion vector

- Compute hamming distance of the descriptors from two following images
- Find minimal match  $\rightarrow$  Greedy algorithm
- $\rightarrow$  Motion vectors
- Find essential matrix  $\rightarrow$  5-Point algorithm
- Find rotation and translation matrix



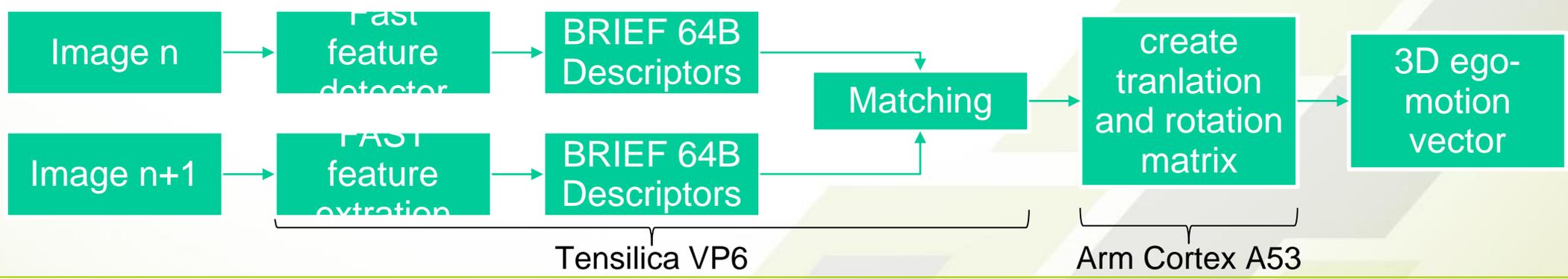
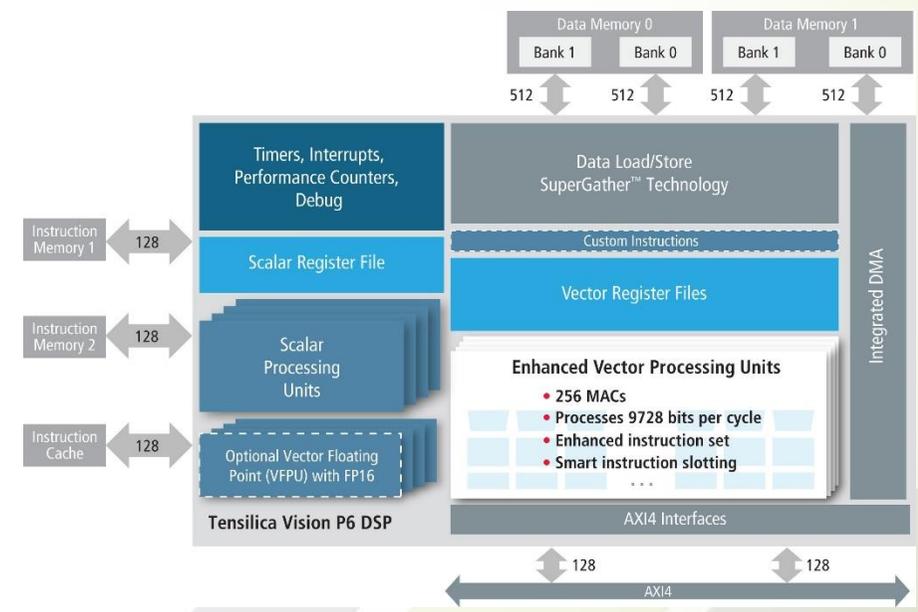
## SDIP SoC (Things2Do Project)

- VIU: Video input unit
- MVDU: Multistream video display unit
- Arm Cortex A53
- Tensilica Vision P6
  - Level 1 Cache, 2x 256kB
  - Level 2 Cache, 2x 1MB

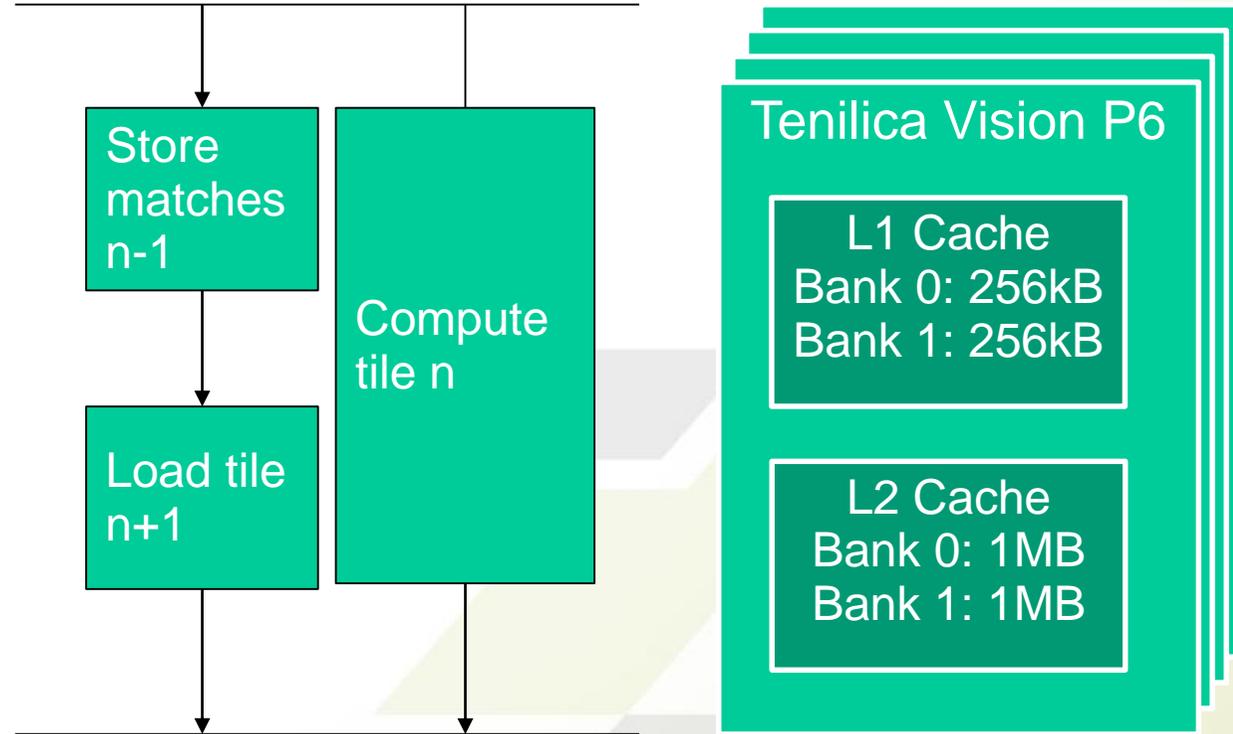
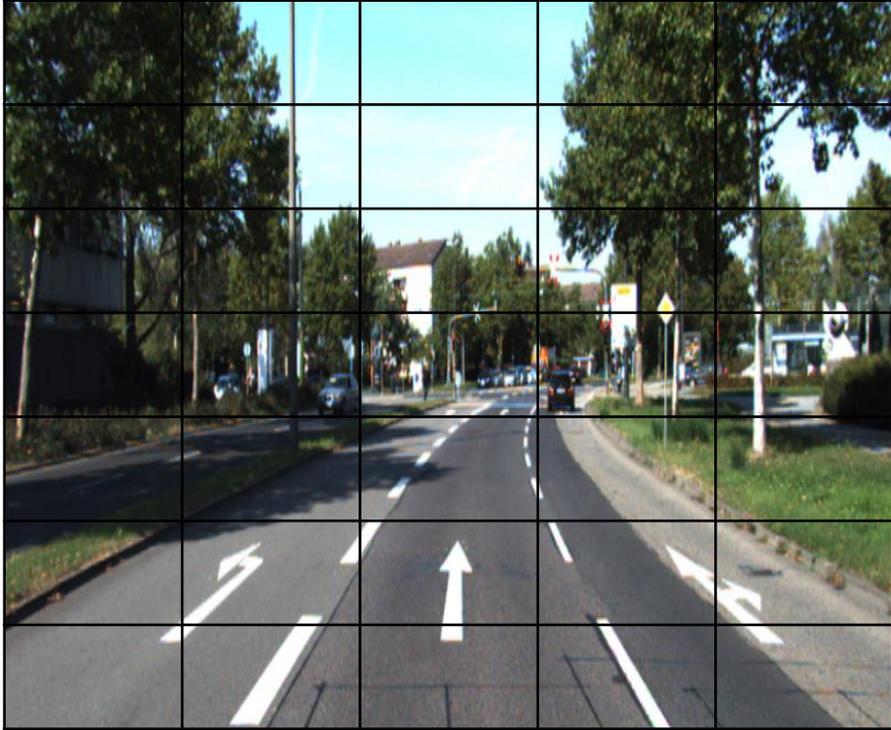


# Algorithm: Ego Motion Estimation

- XI Library:
  - FAST, BRIEF
- Vector types 512b width
  - 64x int 8b, 32x int 16b, 16x int 32b
- Instruction set for the Vision P6 to compute vector types
- One descriptor can be stored in one vector register (64B descriptpor)
- Only save matches to shared memory (DDR)

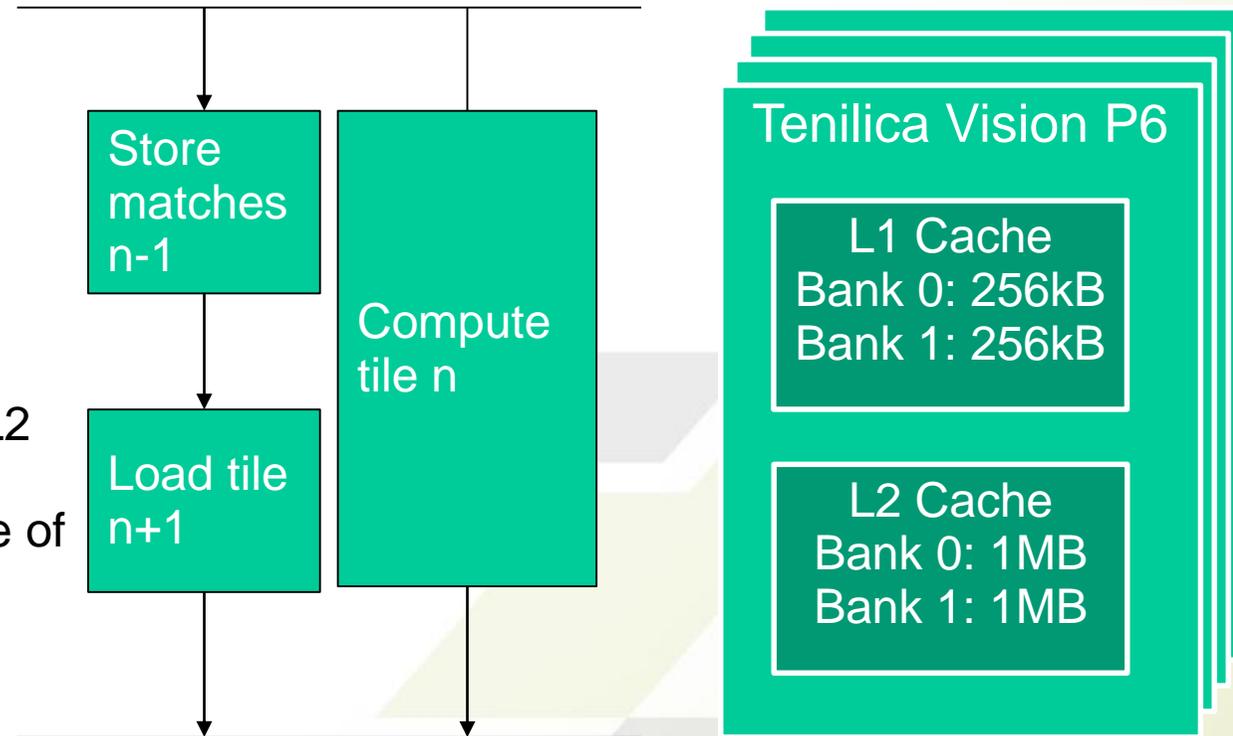


## Implementation on Tensilica Vision P6



## Implementation on Tensilica Vision P6

- Use the DMA
- Use different banks to load/store and process in parallel
  - Reduce execution time
- Load the tiles in the L1 Cache
- Compute FAST and BRIEF
- Store all descriptors of the image in the L2 Cache
- Match the descriptors from the L2 Cache of two following images
- Store the matches in the DDR
  - Reduce load and store operations





## Ego Motion Estimation

- Interfaces
  - Input: Mono Grayscale Image, 30fps
  - Output: Ego motion vectors
- C model using OpenCV
- Target platform
  - SDIP SoC (Things2Do Project)
    - ADAS - High performance platform
    - 4x Tensilica VP6, 4x Arm Cortex A53



# THANKS

