Passive Dense Stereo Vision On The Myriad2 VPU

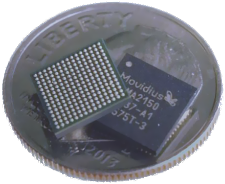
Luca Puglia [1] Mircea Ionică [2]
Giancarlo Raiconi [1] David Moloney [2]

[1]Universita' degli Studi di Salerno, Italy - {lpuglia,gianni}@unisa.it

[2]Movidius Ltd. - {mircea.ionica,david.moloney}@movidius.com

Stereo Vision with less than 20$

- In recent years the demand for computer vision in robotics, drones and security applications has been increasing steadily
- Important considerations in the building of a fleet/swarm of robots are power management and the cost of each element.
- Without an affordable and power-efficient solution, further progress in this field will be limited by these considerations.
- Thanks to Myriad2 it is possible to perform video processing in severely power-constrained environments.
- This work presents an Adaptive Semi-Global Matching technique for stereo vision on Myriad2.



The Algorithm

- The starting point for this work is the algorithm presented in [1]
- The Semi-global version we have implemented restricts the disparity depth range
- In order to boost the performance on the Myriad2 VPU, an adaptive depth range is used
- At every iteration the maximum disparity is computed
- According to this, the depth range increases or decreases over subsequent iterations

Let IL_x and IR_x be the $x - th$ homologous lines in the left and right images, w their length, dr the number of depth range, $\mathcal{M}$, $\mathcal{GAP}$ and $\mathcal{EGAP}$ respectively the Match score, the GAP and Extended GAP penalties (both constant) and $\mathcal{MS}$, the MiSmatch score, set proportionally to the pixel relative distance in RGB space. Our implementation fills a Score Volume $(dr * w)$ using the following procedure:

$PROCEDURE(dr)$
for $i = 1 \dots w$ **do**
  for $j = i \dots (i + dr)$ **do**
    $\mathcal{MS} = -|IL_x(j) - IR_x(i)|$
    if $is\_GAP(M(i-1, j))$ **then**
      $nord \leftarrow M(i-1, j) + \mathcal{EGAP}$
    else
      $nord \leftarrow M(i-1, j) + \mathcal{GAP}$
    end if
    $diag \leftarrow M(i-1, j-1) + \mathcal{M} + \mathcal{MS}$
    if $is\_GAP(M(i, j-1))$ **then**
      $west \leftarrow M(i, j-1) + \mathcal{EGAP}$
    else
      $west \leftarrow M(i, j-1) + \mathcal{GAP}$
    end if
    $M(i, j) \leftarrow max(north, diag, west)$
  end for
end for
$max\_disp = DISP\_COMP(M)$
return max_disp

[1] R. Dieny, J. Thevenon, J. M. del Rincon, and J.C. Nebel, "Bioinformatics Inspired Algorithm for Stereo Correspondence," in VISAPP 2011 - Vilamoura, Algarve, Portugal, 5-7 March, 2011.

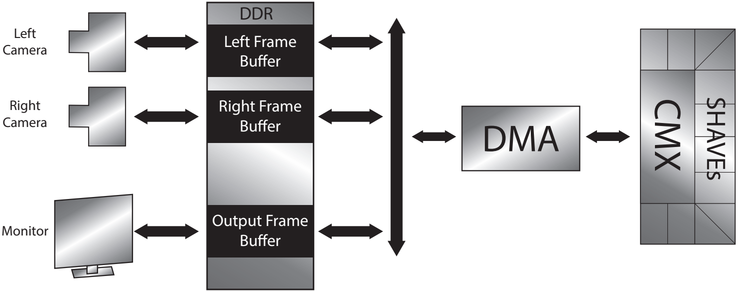
Architecture and Implementation

- The input and output buffers reside both in the main memory
- The input buffers are filled by two cameras while the output is read by a display interface
- A Direct Memory Access (DMA) controller is programmed to copy image slices to the cores' local memory, where they are processed
- When a core finishes computing, the results are copied back to the main memory, into the output frame buffer
- In order to speed up the algorithm, each core has a maximum depth range dr.

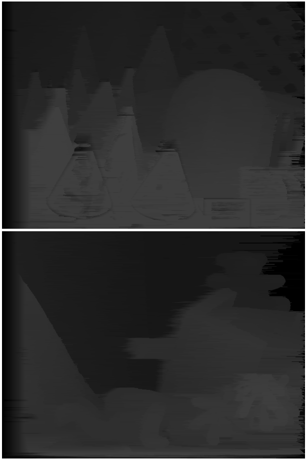
- The dr parameter is adaptive:

$dr \leftarrow 32$
while $true$ **do**
    $max\_disp = PROCEDURE(max\_disp)$
    if $dr = max\_disp$ **then**
        $dr \leftarrow dr + 1$
    else
        $dr \leftarrow dr - 1$
    end if
end while

- This behaviour results in performance boosting, since fewer comparisons are needed.



Results and Conclusion



- Desktop CPU (i7-4558U @ 2.80GHz): time to compute one frame 5.4s
- Development effort for FPGA: 6 man-months
- Development effort for Myriad2: 2 days
  - Image Size 640 $\times$ 480
  - FPS: 8..50
  - Disparity depth: 64..10