Embedded Real-time Stixel Computation

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Abstract

The Stixel World is a medium-level, compact representation of road scenes that abstracts millions of disparity pixels into hundreds or thousands of stixels. The goal of this work is to implement and evaluate a complete multi-stixel estimation pipeline on an embedded, energy efficient, GPU-accelerated device. This work presents a full GPU-accelerated implementation of stixel estimation that produces reliable results at 26 frames per second (real-time) on the Tegra X1 for disparity images of 1024 × 440 pixels and stixel widths of 5 pixels, and achieves more than 400 frames per second on a high-end Titan X GPU card.
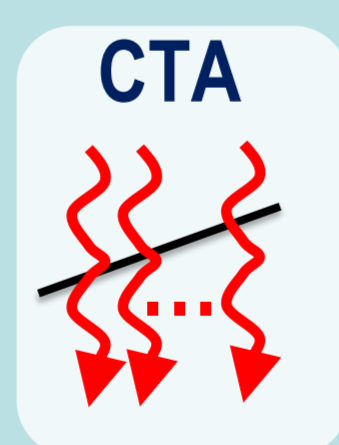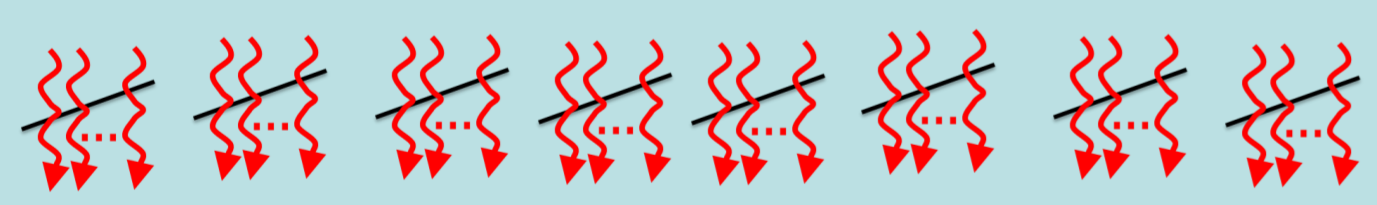
Problem: Compact depth representation

Stereo Images

Stereo + Horizon Line + Road Slope

Stixels

Sky
Object
Object
Object
Ground
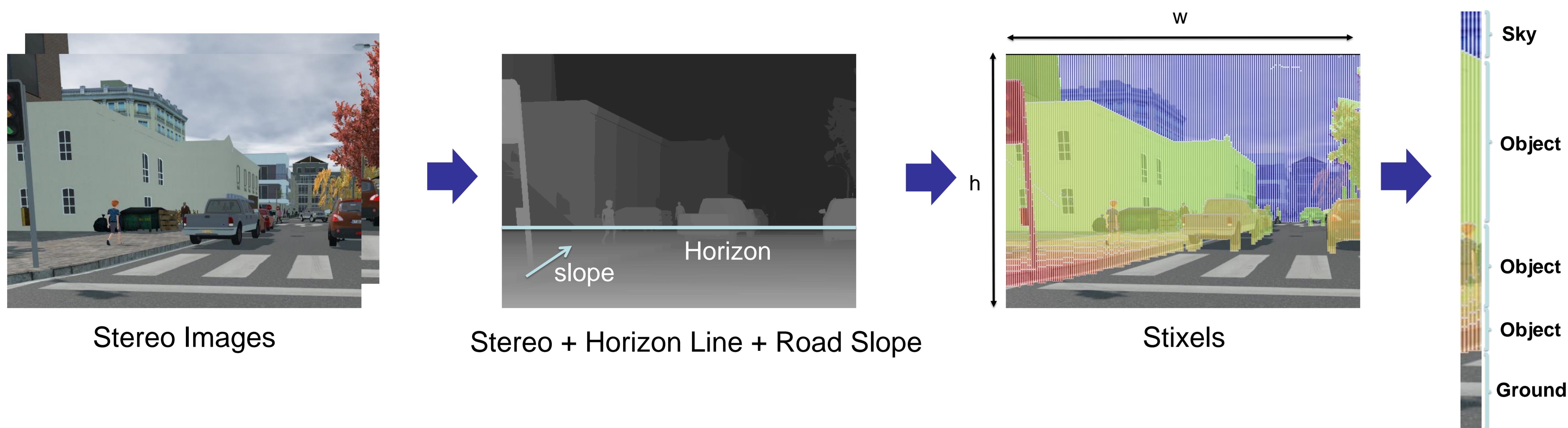
Stixels Overview

- **Goal: Compact depth representation**
- **Extensions: tracking, grouping, semantics**
- **Dynamic Programming algorithm**
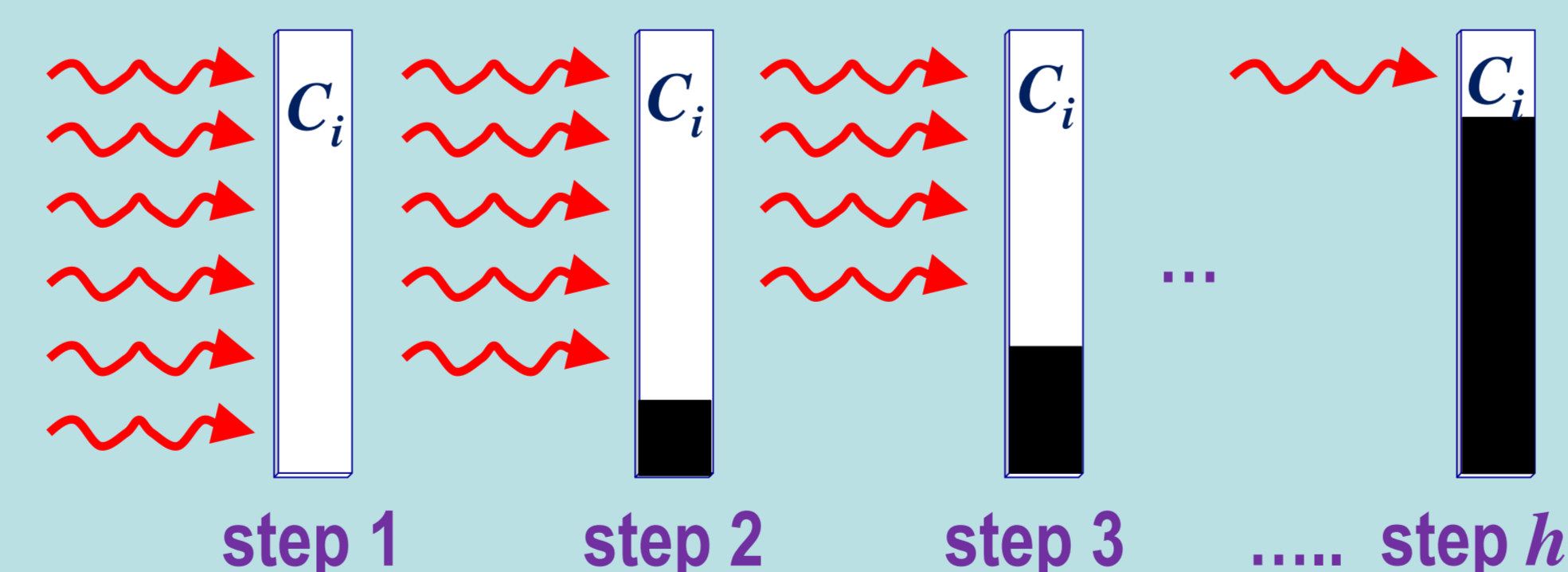- **High computational complexity $O(w \times h^2)$**

Parallelization

First level parallelism

CTA

- **Independent / Task level: Typical CPU parallelization**
- **Each image column is processed by a CTA**

Second level parallelism

C_i C_i C_i ... C_i

step 1   step 2   step 3   ..... step h

- **Extra parallelism level needed for efficient GPU use**
- **Sequentially perform h (image height) steps**
- **CTA threads collaborate sharing info each step**
- **Decreasing Parallelism: Each step uses one thread fewer**

Results

	FPS	Speed Up	FPS / Watt
CPU Muti-thread	13.3	1	0.10
GPU Optimized	413	31	1.65
NVIDIA Drive PX[1]	26	1.95	2.6

CPU: Intel Core i7 980X
GPU: NVIDIA Titan X
Drive PX: NVIDIA Tegra X1

Image Size: 1024x440

[1] single-socket
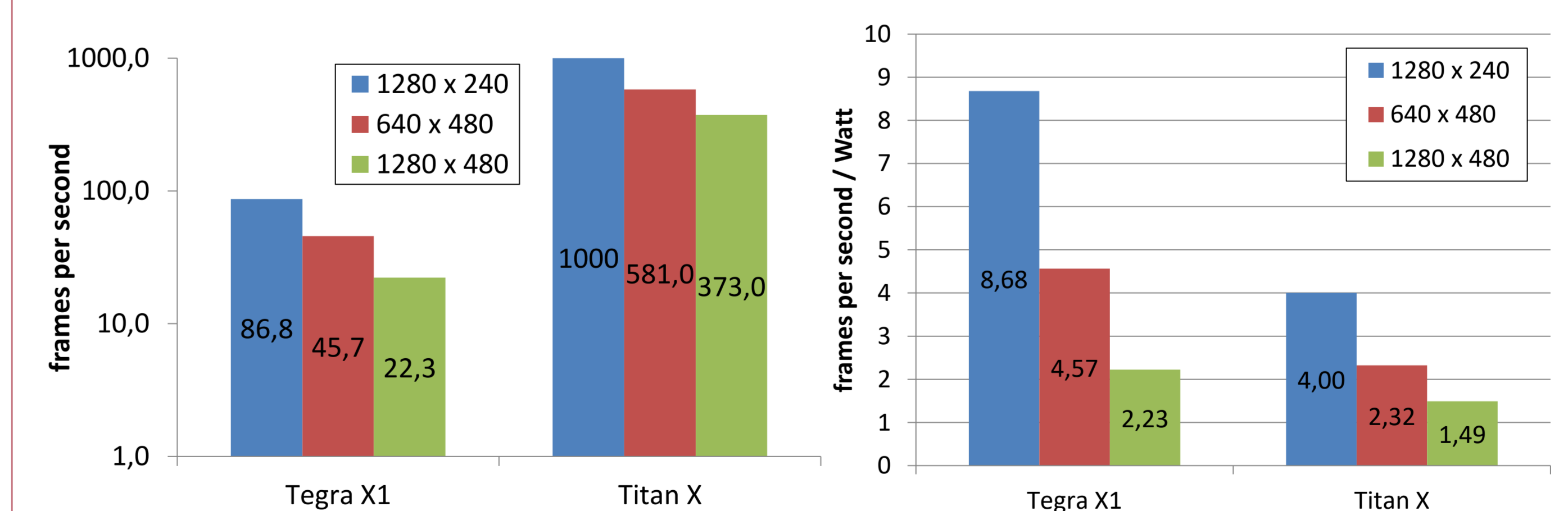
Conclusions:
- Real-time performance for energy efficient GPU NVIDIA Tegra X1.
- NVIDIA Tegra X1 has better energetic efficiency than high-end GPUs.

References:
[1] D. Pfeiffer and U. Franke. Towards a global optimal multilayer stixel representation of dense 3D data. In British Machine Vision Conference, BMVC 2011, Dundee, UK, August 29 - September 2, 2011. Proceedings, pages 1–12, 2011.