Complete Workload Analysis of Real Autonomous Driving System: Apollo, Baidu Inc.

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***Abstract*—Autonomous driving is a field that gathers many interest from the academics world and from industry leaders. The software of an autonomous driving systems (ADS) incorporates the state-of-the-art from many disciplines, such as computer vision, robotics, geolocalization. Although the high level architecture of an autonomous driving system and the main algorithms used are known, the complete analysis of a real ADS is still difficult, especially for what concerns the modules interdependencies, interactions, either software and hardware, and pre- and post-processing.**
In this paper, we want to extract those point of views and quantify them according different architectural aspects: response times, memory movements, complexity and CPU-GPU relationship.
The analysis is based on the open-source Apollo ADS developed by Baidu and is focused on the most important modules: perception, prediction and planning.

I. Introduction

Autonomous driving system has several design constraints [1] to be met in order to produce a safe and reliable output.

Response time [1] is crucial for the predictability and accuracy of the system, especially when multiple sensor and components are present, each of them with a processing routine associated. The maximum response time, that has been adopted as standard in the field of autonomous driving, is 100 ms and should ensure a proper and safe reaction to any possible situation. Several processing routines use time deltas to perform corrections and projections of input and if those time-deltas are exceeding context-related thresholds then the input is discarded, losing some potential useful information, so limiting the response time will affect also the accuracy of the system.

Autonomous driving requirements.
Introduction to Apollo: what is it, how is it implemented, data communication.
Modules that are going to be analyzed.
Image of apollo software architecture.

II. Perception

Perception diagram. General description: what it does, sensors descriptions, output and general overview.

For each component: camera, lidar segmentation, lidar recognition, fusion component and traffic lights

A. Camera Component

1) What it does and how: Explain which are the input of module, output and tasks. Explain what each task does.

2) Complexity: Explain the complexity of the tasks and their dependencies

3) Response time: Response time analysis and on which device each task runs. Table or graph about response times.

B. Lidar Segmentation Component

1) What it does and how: Explain which are the input of module, output and tasks. Explain what each task does.

2) Complexity: Explain the complexity of the tasks and their dependencies

3) Response time: Response time analysis and on which device each task runs. Table or graph about response times.

C. Lidar Recognition Component

1) What it does and how: Explain which are the input of module, output and tasks. Explain what each task does.

2) Complexity: Explain the complexity of the tasks and their dependencies

3) Response time: Response time analysis and on which device each task runs. Table or graph about response times.

D. Fusion Component

1) What it does and how: Explain which are the input of module, output and tasks. Explain what each task does.

2) Complexity: Explain the complexity of the tasks and their dependencies

3) Response time: Response time analysis and on which device each task runs. Table or graph about response times.

E. Traffic Light Component

1) What it does and how: Explain which are the input of module, output and tasks. Explain what each task does.

2) Complexity: Explain the complexity of the tasks and their dependencies

3) Response time: Response time analysis and on which device each task runs. Table or graph about response times.

III. Prediction

IV. Planning

V. Memory Throughput Simulation

Analyze the impact of accelerating, through a PCI device, the inference of CNN in terms of memory movements from the GPU/CPU to PCI Device.

VI. Simulation Details

Datasets, gpu, cpu, software used and so on

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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E. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited,

such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)

- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively".
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TABLE I
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	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

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ACKNOWLEDGMENT

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REFERENCES

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