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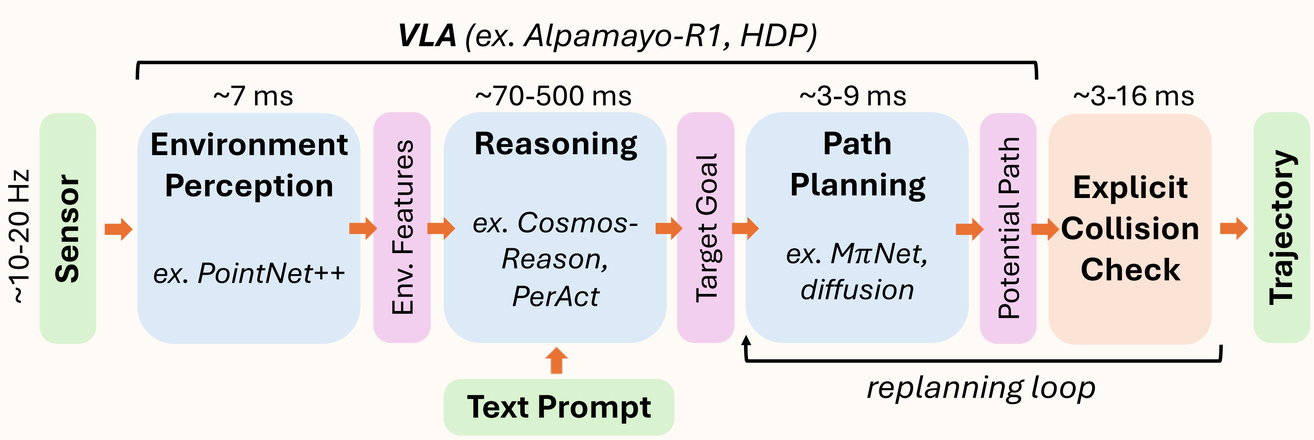
RoboGPU:
Accelerating GPU Collision Detection for Robotics

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University of British Columbia

Website + Code

Come to our talk! ***Nov. 4 @ 11:55AM***

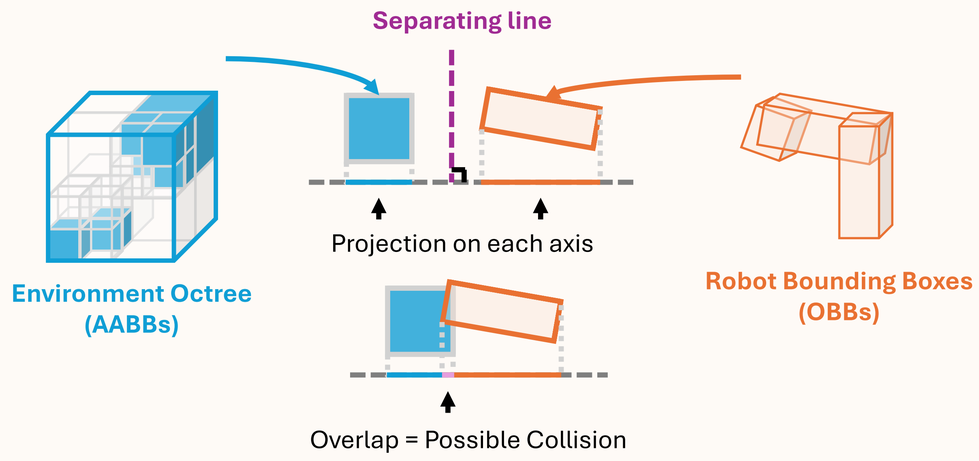
Neural Networks in Robotics



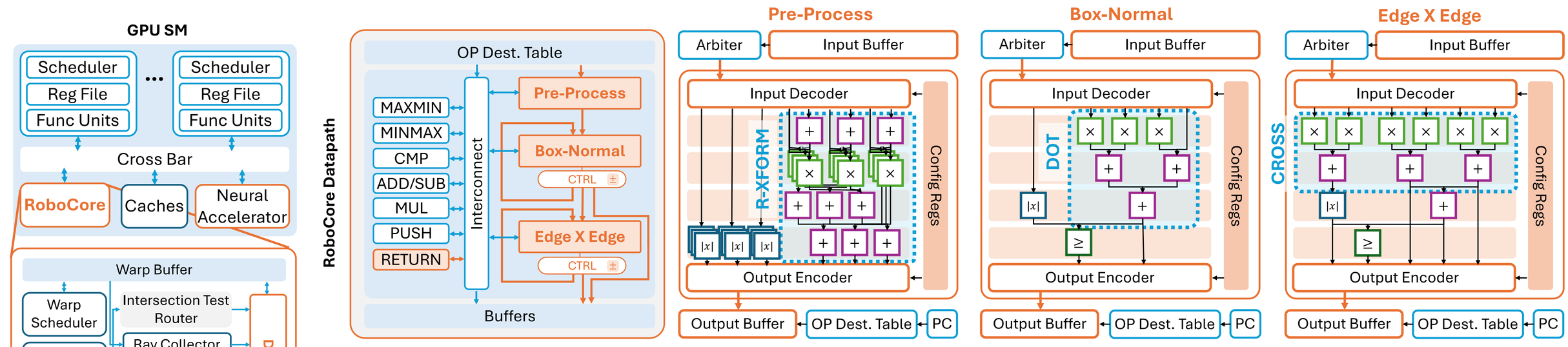
- Collision detection is the bottleneck in neural motion planning.
- Neural planners can have up to **14%** collision rate on successfully generated paths [1].

Collision Detection

- Explicit collision detection can be approximated with boxes, using the separating axis collision test.
- 15 axis tests (with possible early exit) are required.



Specialize GPUs for faster and safer robotics



RoboGPU replaces ray tracing accelerators (RTAs) with RoboCore for robotics-specialized GPUs.

RoboGPU Design *Accelerate collision detection + support future robotics workloads.*

Specialization

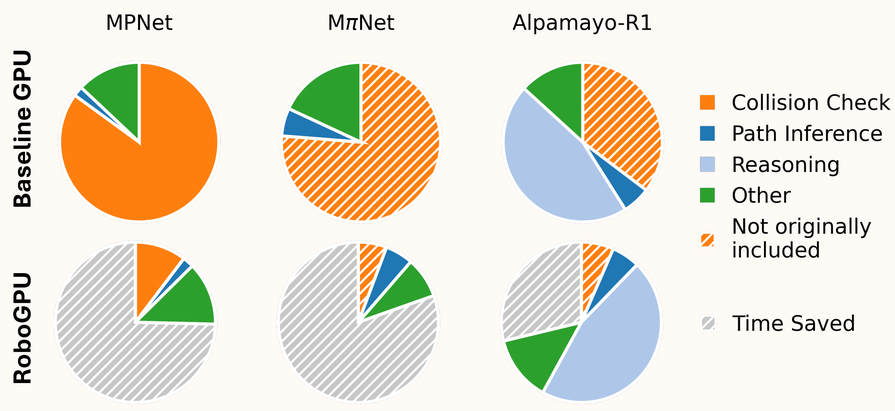
- Dedicated collision detection hardware with three new OP units
- Added support for early exit conditions

Programmability

- Enabled by TTA+ [2] with dual-purpose OP units to support wide range of robotics kernels
- Accelerates classical algorithms while accommodating the growing field of robotics

Results *Evaluated with RoboCore modeled in Vulkan-Sim [3].*

- ✓ **13.3**× faster than CUDA and **2.8**× faster than Mochi [4] (RTA).
- ✓ **48%** less energy with **2%** more area than RTAs.



- ✓ **3.4**× end-to-end speedup on MπNet [1] with accelerated point cloud processing.
- ✓ Eliminates collisions in generated paths.

Other Robotics Workloads

- ✓ **1.1**× faster on RoWild DeliBot [5] (Monte Carlo Localization) than baseline GPU.
- ✓ **1.2**×-**1.9**× faster on point cloud processing than RTA.

References

1. A. Fishman, A. Murali, C. Eppner, B. Peele, B. Boots, and D. Fox, "**Motion policy networks**," in CoRL, 2022.
2. D. Ha, L. Liu, Y. Chou, S. Go, W. Ro, H-W. Tseng, and T. M. Aamodt, "**Generalizing ray tracing accelerators for tree traversals on GPUs**," in MICRO, 2024.
3. M. Saed, Y. H. Chou, L. Liu, T. Nowicki, and T. M. Aamodt, "**Vulkan-Sim: A GPU architecture simulator for ray tracing**," in MICRO, 2022.
4. D. Mandarapu, N. James, and M. Kulkarni, "**Mochi: fast & exact collision detection**," arXiv preprint arXiv:2402.14801, 2024
5. M. Bakhshalipour, and P. B. Gibbons. "**Agents of autonomy: A systematic study of robotics on modern hardware**," in POMACS, 2023

RoboGPU

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