ACTS for IRIS-HEP

Rocky Bala Garg

on behalf of Berkeley & Stanford IRIS-HEP teams

IRIS-HEP Institute Retreat
October 12-14, 2022
ACTS (A Common Tracking Software)

- Open source tracking framework
- High level track reconstruction modules
- Initial effort started from ATLAS tracking algorithms
- Can be used with different detector geometries
- Supports multi-threaded event processing
- ACTS links:
Past Year’s Accomplishments - Stanford

- Implemented automatic tuning techniques in ACTS framework for track seeding and vertexing
  - Results presented in Connecting The Dots 2022: [Link to talk](#)
  - Dedicated session in ACTS Developers’ Workshop: [Link to talk and tutorial](#)
  - Python based code available in ACTS main framework: [Link](#)
  - Preliminary studies with ATLAS-ITk geometry
- ACTS integration into Athena:
  - Integrated ACTS’ Iterative vertex finder (IVF) algorithm within ATLAS’ Athena framework
  - [Link to Internal Note](#)
Past Year’s Accomplishments - Berkeley

○ GPU tracking (Beomki)
  ○ GPU track reconstruction demonstrator (traccc): clusterization and seeding
  ○ GPU tracking geometry builder (detray): track propagation in ACTS TrackML detector
  ○ Around 10x speedup over single core CPU. Results presented at CTD 2022: Link to talk

○ ACTS/Athena Integration (Carlo):
  ○ Integration of ACTS based seeding into Athena
  ○ Introduction of Monitoring algorithms for several stages of the track reconstruction
  ○ Co-organized ACTS Developers’ Workshop

○ Non-linear Kalman Filter (Heather)
  ○ Developed a non-linear Kalman Filter with improved performance (with former IRIS-HEP member, Xiaocong Ai)
  ○ Paper under review at NIM: https://arxiv.org/abs/2112.09470

○ ML Based Kalman Filter (Max, Johannes, Heather)
  ○ IRIS-HEP fellow Max Zhao explored ML based approaches to the Kalman Filter: Link to talk
Next Year’s Plans (Stanford)

- Auto-tuning algorithm development for different $\eta$ bins (Augstin)
  - Independent optimization of track seeding parameters for different $\eta$ regions
- Developing and integrating C++ based auto-tuning framework (Rocky)
  - Completely C++ based optimization
  - Automatize as much as possible
  - Make it an integrated part of ACTS Core software
- Auto-tuning studies with ATLAS ITk Geometry (Rocky)
- ACTS vertex algorithm maintenance (Bastian, Rocky) – Currently not supported by IRIS-HEP
- PV-Finder with ACTS (Bastian, Rocky)
  - Currently, PV-Finder algorithm has been studied with ATLAS data
    - Results are under approval with ATLAS Tracking Conveners for poster presentation at ACAT2022
  - Plan is to use ACTS simulated data with PV-Finder
  - Integrate PV-Finder into ACTS framework
Next Year’s Plans (Berkeley)

○ ACTS-Athena integration:
  ○ Interoperability of the track reconstruction algorithm: adapt the code so that for each stage we can choose either an Athena or an Acts-based algorithm (for validation purposes)
  ○ Introduce EDM converters to support the above design
  ○ Restructure Job Option of Athena reconstruction
  ○ Coordinate the efforts in the EF Tracking community: concerning the Track Extension, Fitting and Ambiguity Resolution in L4 area
    ○ potential to use ACTS algorithms for the trigger

○ GPU Tracking:
  ○ Optimize the currently implemented algorithms
  ○ Include the detray geometry in the traccc pipeline
  ○ Develop GPU (Combinatorial) Kalman Filtering using the detray geometry
  ○ Migrate traccc codes into ACTS main repository
  ○ Develop the translation of ACTS geometry into detray geometry
The next 5 years : ACTS (Inputs from Andreas Salzburger, CERN)

○ ACTS Core
  ○ Conservative Milestones
    ○ Consolidation of full reconstruction chain
    ○ Addition of Calorimeter + Muon system description
    ○ Merge of primary + secondary vertexing packages into one vertexing code base
  ○ R&D Projects Conclusion
    ○ Inclusion of R&D code into main framework (GPU, ExaTrkX, Auto-tuning)
  ○ Investigation: Make track parameterization compile-time configurable (to natively support telescope, forward + fix target experiments)

○ ACTS for ATLAS
  ○ ACTS plays a key role in the ATLAS plans for the Roadmap to Run 4
  ○ ATLAS currently aims to use ACTS for ITk to Run 4
    ○ Included in the ‘conservative scenario’ to reduce CPU usage
  ○ Opportunities currently being explored to use ACTS for Event Filter Tracking (Carlo is one of the sub-conveners)
  ○ New approaches highly welcome
    ○ Opportunity for IRIS-HEP through development of ML and GPU algorithms
The next 5 years: Stanford & Berkeley

Stanford:
- Fully build out ACTS-ML tools integration
- First two targeted algorithms – Auto-tuning/optimization & PV-Finder
- Collaborate on ML for tracking projects/or possibly ACTS for the Event Filter

Berkeley:
- ACTS for ITk in Athena (full tracking chain & used by ATLAS)
- end-to-end tracking on GPU demonstrator
- ML based Kalman-Filter
- Opportunity: ACTS for the Event Filter
Thank you!!!
Back-up
Some useful figures

Clusterization (Single Precision)
CPU: i7-10750H (single core) / GPU: RTX 2070

Seeding (Single Precision)
CPU: i7-10750H (single core) / GPU: RTX 2070

Propagation (Single Precision)
CPU: i7-10750H (single core) / GPU: RTX 2070