Accelerometry-based inference of constrained motions

Chris Isaac Larnder, John Abbott College

Fonds de recherche Nature et technologies Québec

Summary

Reconstruction of motion from accelerometer data is, in the general case, difficult:
- Einsteinian *proper acceleration* : separate into gravitational and coordinate-acceleration components
- double-integration techniques: noise-amplification "drift"
- signal conditioning

Motions subject to mechanical constraints are more docile. Exploit:
- reductions in the degrees of freedom
- coupling of 2nd-order kinematics with lower-orders. Eg:
  - radial acceleration --> angular velocity
  - gravitational orientation --> angular position
- redundancy opportunities for Bayesian filtering

Anticipated low-level feature-extraction capabilities:
- constrained DOF's:
  - tracking of the invariant or slowly-varying properties of the system
- unconstrainted DOF's:
  - robust estimates of the (higher-variability) state variables
- sensor signal:
  - positioning, alignment; calibration, linearity; smoothing, channel "cross-talk"

Constraints:
- detection of elemental low-DOF "constraint signatures":
  - rotating, rolling and sliding contact scenarios
  - mechanical and biomechanical joints
- all "in situ", under realistic load and motion conditions

Applications

- "smart" devices:
  - mobile, iOT, wearable, health/fitness
  - "edge computing"
- biomedical:
  - biomechanical and motor-control impairments, rehabilitation, monitoring
- "industry 4.0" :
  - online monitoring, fault detection, robotic control
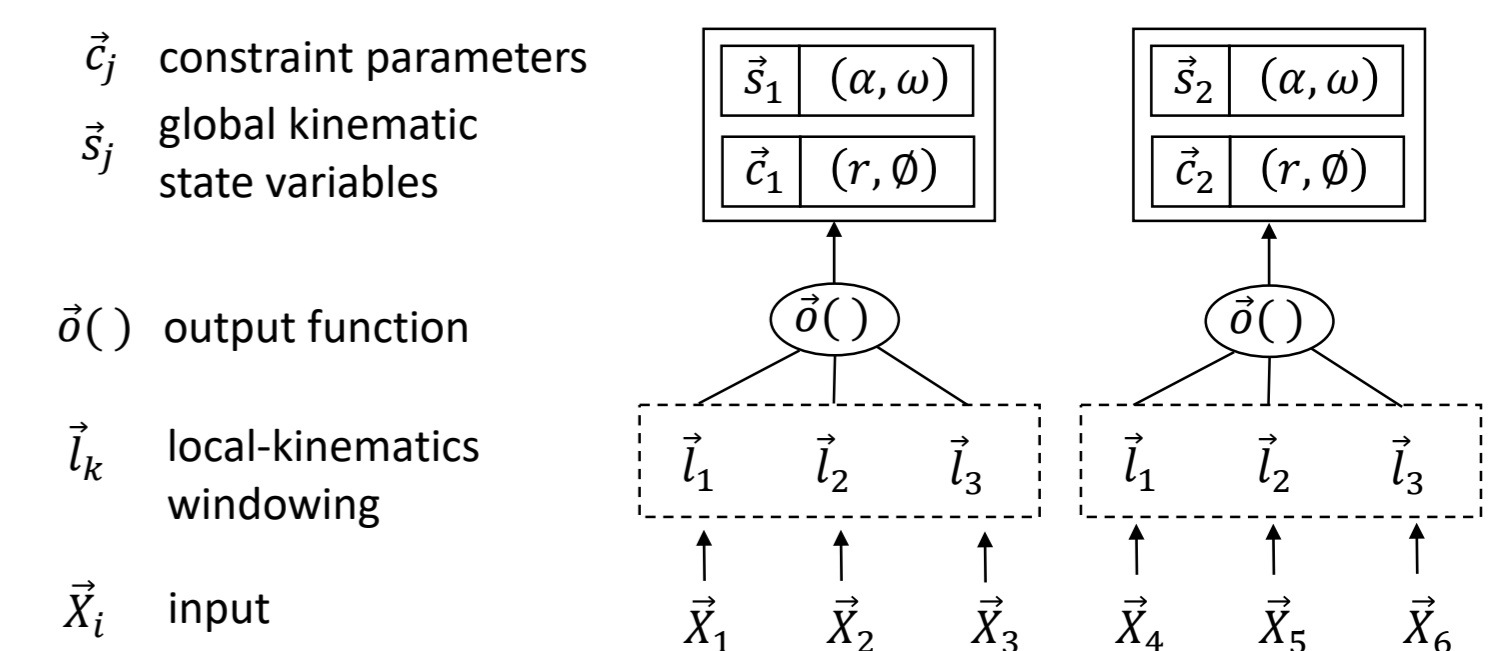
Target Properties

- small:
  - size, power requirements
  - weight, memory footprint
  - gyro-free
- fast:
  - performance, latency
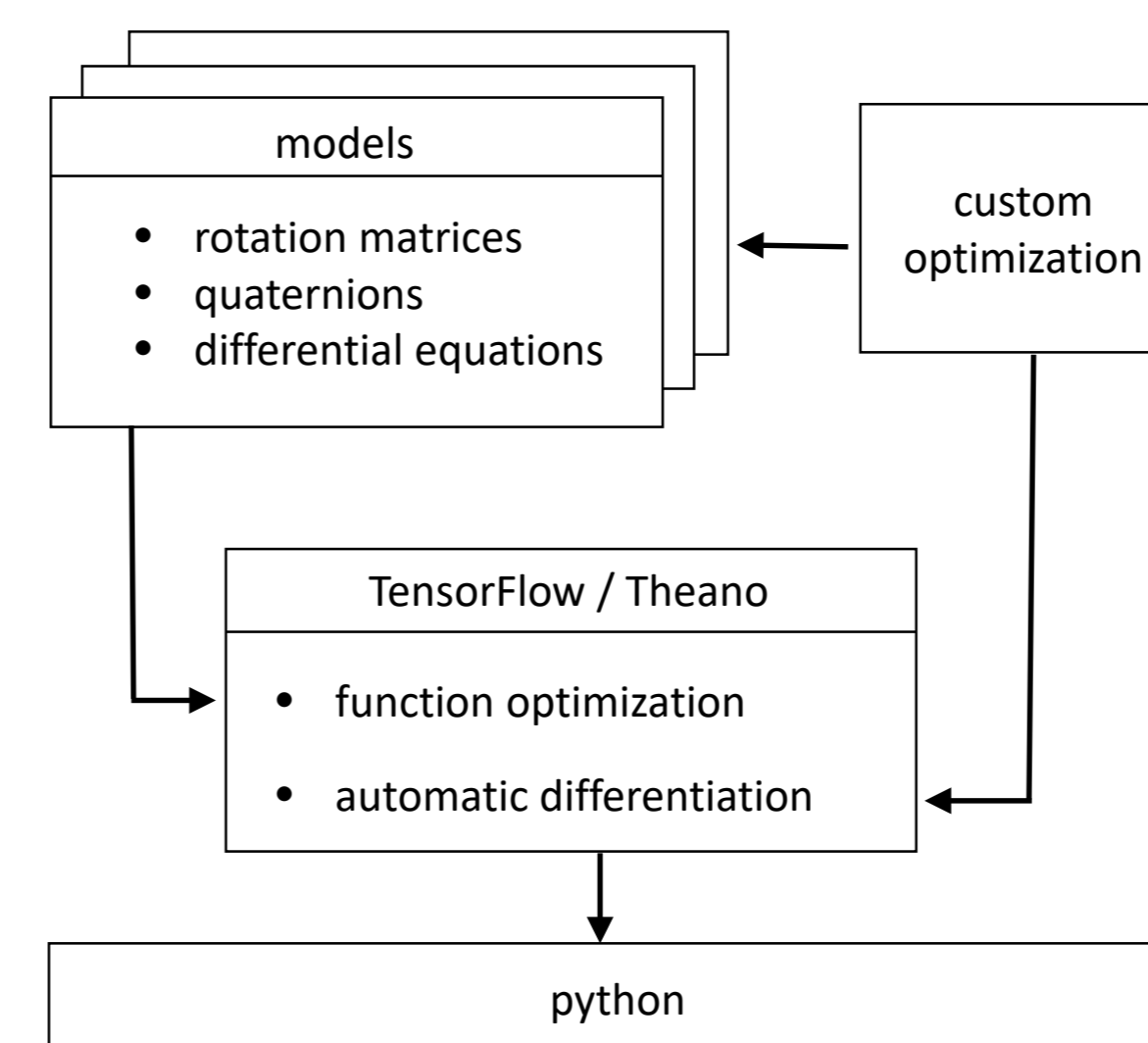
- human-interpretable
  - retargetable component

system layers
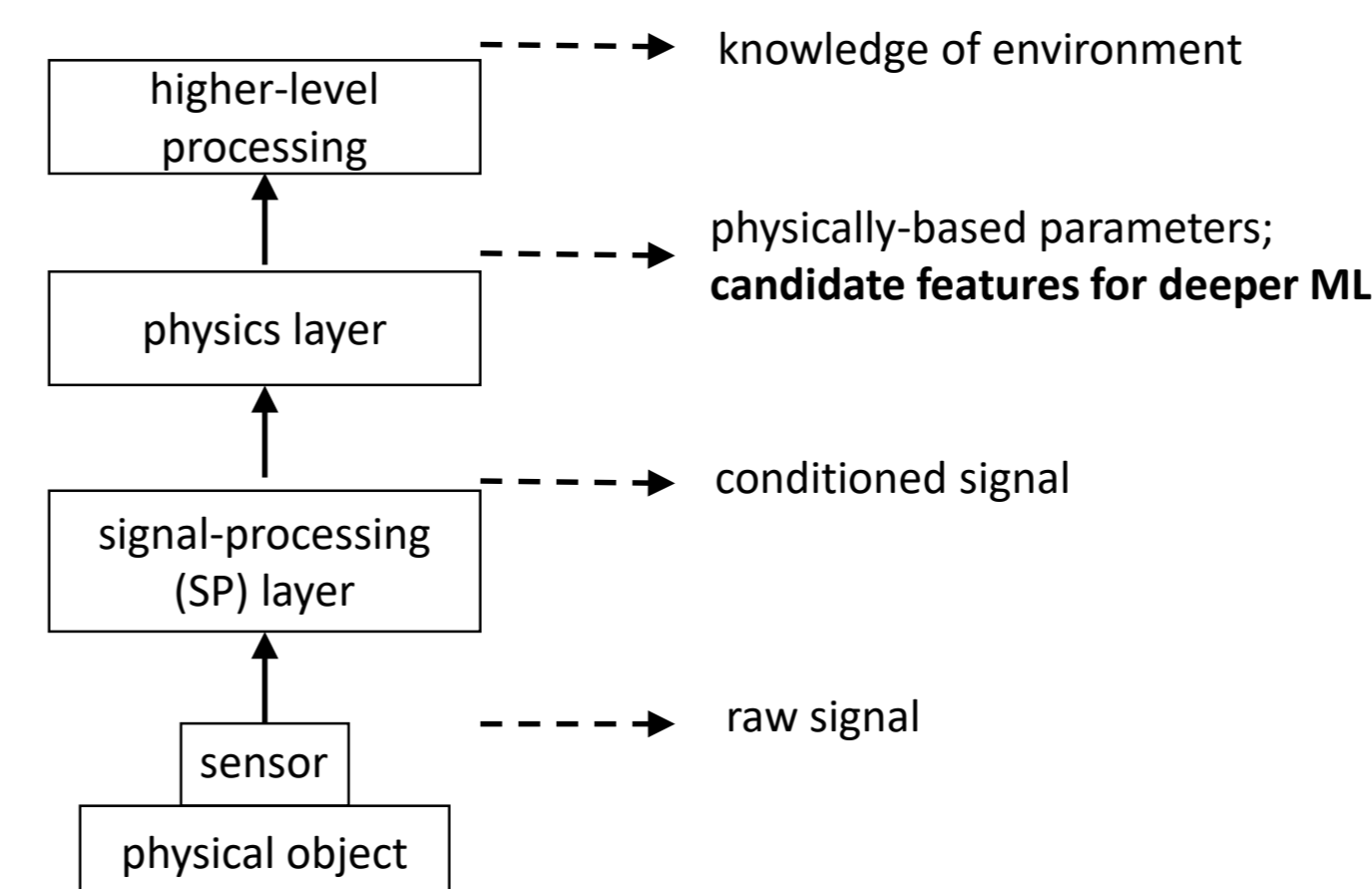
physics-layer processing and output

core software components

physics layer sample architecture