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https://forgetfuldatabases.github.io/

Challenge:

When Cyber-Physical Systems such as V2X use road-friction databases in feedback loops, they face conflicting requirements:

- Databases need to store and share friction data but must also forget "old" data.
- The vehicle collecting friction data is rarely the vehicle using the data.
- High-quality data requires sharp steering, but low-friction stability requires mild maneuvers.

Solutions and Potential Impacts:

- Analytically define "forgetting" using Allan Variance (AVAR) to dynamically identify optimal averaging windows.
- Implement AVAR via database structures that inherently align with the algorithm's operation to accelerate calculations to real-time.
- Create cloud-based context discovery processes to identify active dimensions of data variation, to further reduce data variance.
- Push cloud-discovered context models to roadside edge computers for real-time distributed data sharing in local areas.
- Test results in region-scale traffic simulations and with a live steer-by-wire instrumented vehicle at the PSU test track.
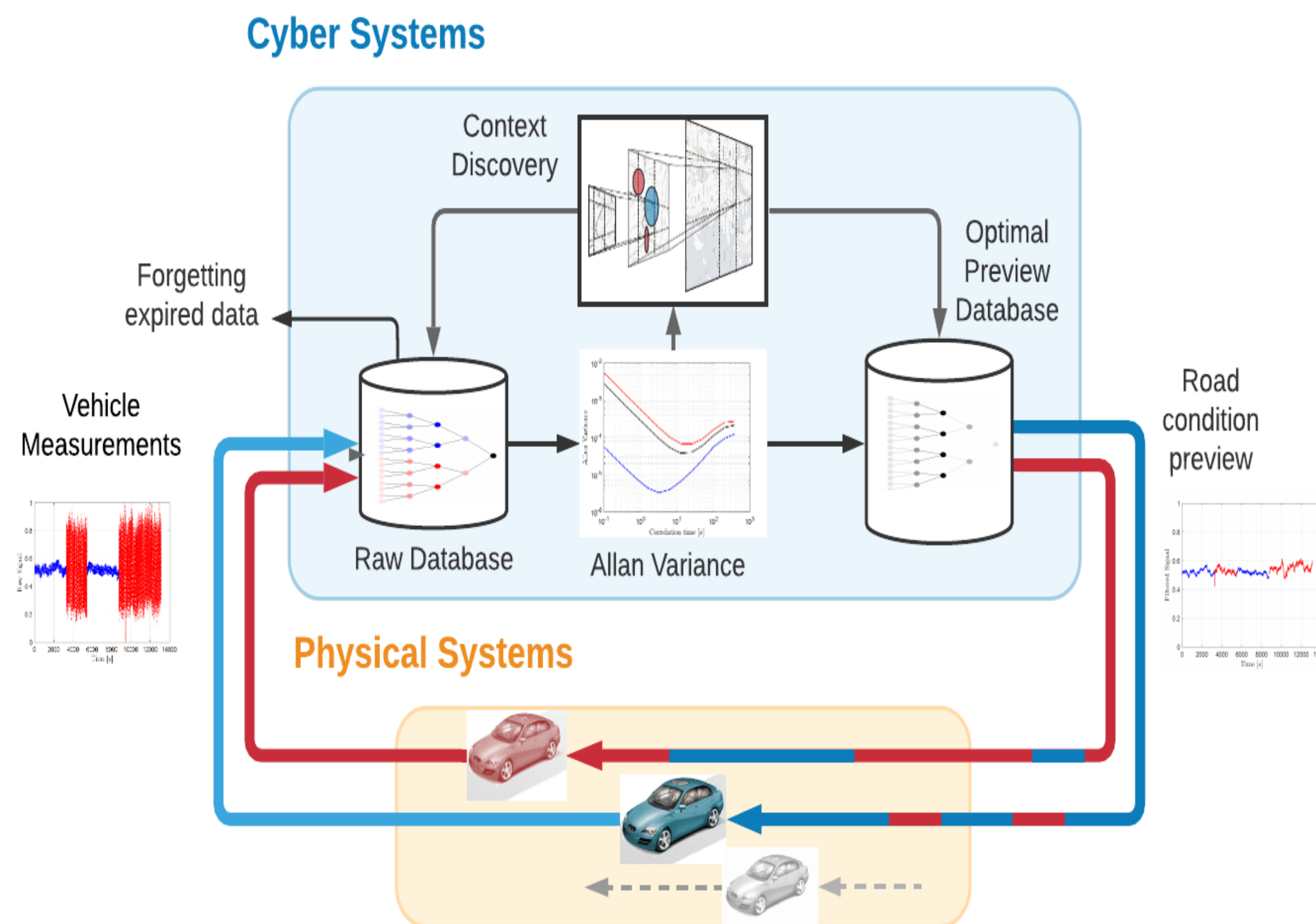
Allan Variance and Context Discovery enable detection of surface friction conditions from a fleet of vehicles via the use of the aggregated data for safe operation of these vehicles.

Broader Impact (education and outreach)

- Developed training codes and small-scale vehicle to support outreach using undergraduate teams.
- Supporting 8 graduate students, 2 are female, 6 are minority.

Scientific Impact (3rd year):

- Demonstrated, via MPC, integration of AVAR databases in long-horizon speed planning and short-horizon lane keeping at high speeds.
- Implemented MPC algorithm in real-time on research vehicle.
- Integrated uncertainty into friction-based control for robust vehicle guidance
- Developed change detection codes via AVAR that show provable best-in-class estimation of statistical variations in time-series data.
- Deployed AVAR as near real-time variants of R and B+ tree systems for databases
- Designed and tested database organization structures to support automated forgetting of "old" data.
- Connected vehicle model, edge model, and cloud in real-time framework.
- Demonstrate real-time sharing of data between the vehicle model and friction database

Broader Impact (impact on society, safety and privacy)

- Privacy: Creating tools to allow personal information to be appropriately "forgotten" with no impacts on data quality of forgetful databases.
- Safety: Enabling vehicle to know the road ahead, to prevent instabilities that currently cause 4,200 accidents a year.