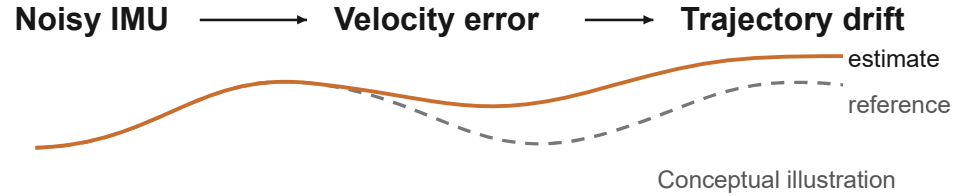
PHIONet: Port Hamiltonian Inertial Odometry Network

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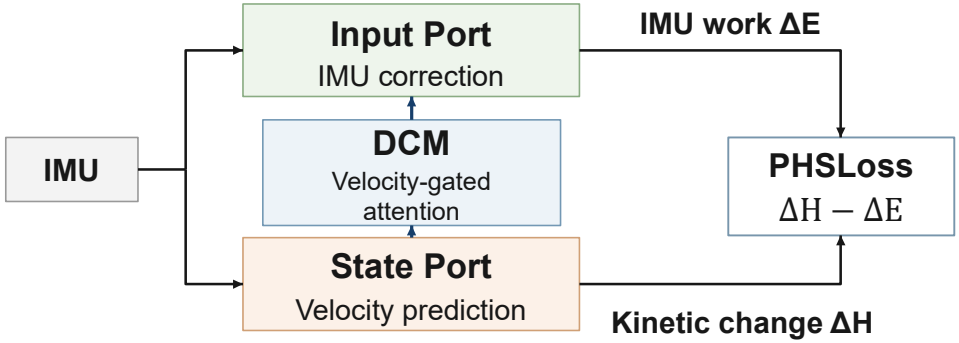
Why inertial estimates drift

Small velocity errors accumulate during aggressive flight.



PHIONet couples IMU correction and velocity prediction through a finite-window work–energy balance.

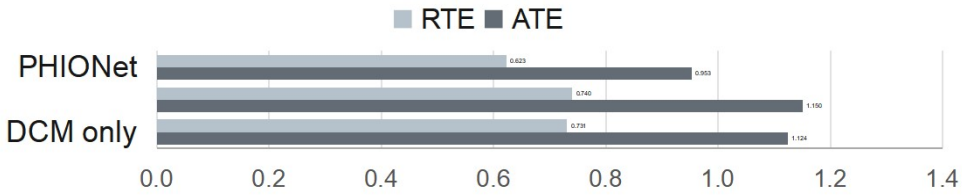
Two ports coupled by physics



$$\Delta H = \tfrac{1}{2}\|v_j^B\|^2 - \tfrac{1}{2}\|v_i^B\|^2$$

DCM learns dissipative IMU corrections from velocity.
PHSLoss adds a soft constraint on work–energy balance.

DCM and PHSLoss work together



Blackbird mean errors (m). Lower is better.

Experiments

Mean ATE reduction vs Air-IO

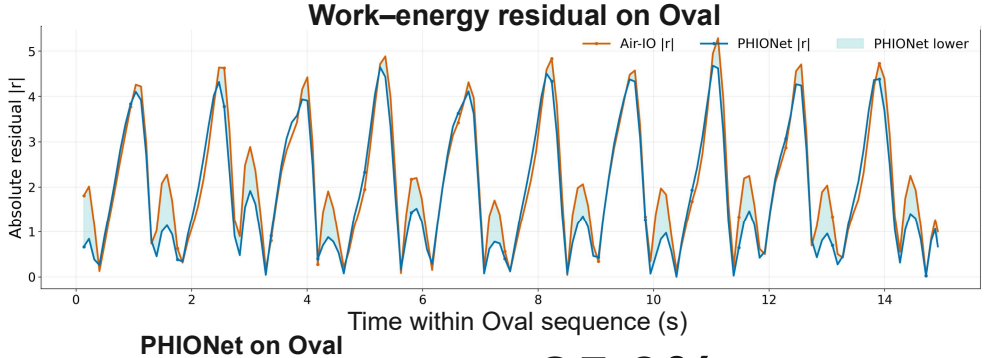
26.7% Blackbird

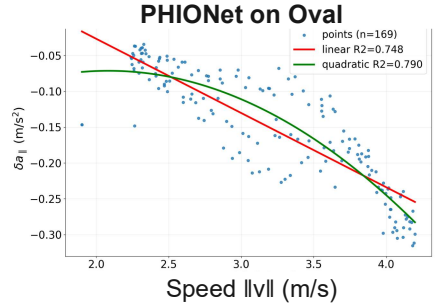
21.8% EuRoC MAV

	Blackbird		EuRoC MAV	
Method	**ATE**	**RTE**	**ATE**	**RTE**
Raw IMU	20.269	2.907	276.849	26.683
AirIMU	21.394	2.895	78.798	9.002
RoNIN	13.487	8.532	6.750	2.516
TLIO	3.478	3.541	6.969	3.052
IMO[1]	9.015	5.962	7.586	2.980
Air-IO	1.300	0.853	3.845	1.198
PHIONet	**0.953**	**0.623**	**3.008**	**1.144**

Mean errors (m), five sequences per dataset. RTE: 5 s windows.
Separate training, open-loop integration. [1] IMO also uses thrust.

Energy consistency in flight





25.9%

Lower median energy residual
1.926 to 1.427

Drag-like correction

Opposes velocity and grows in magnitude with speed.
Quadratic fit $R^2 = 0.790$