Embedded LS-PIV for Measuring Stream Flows

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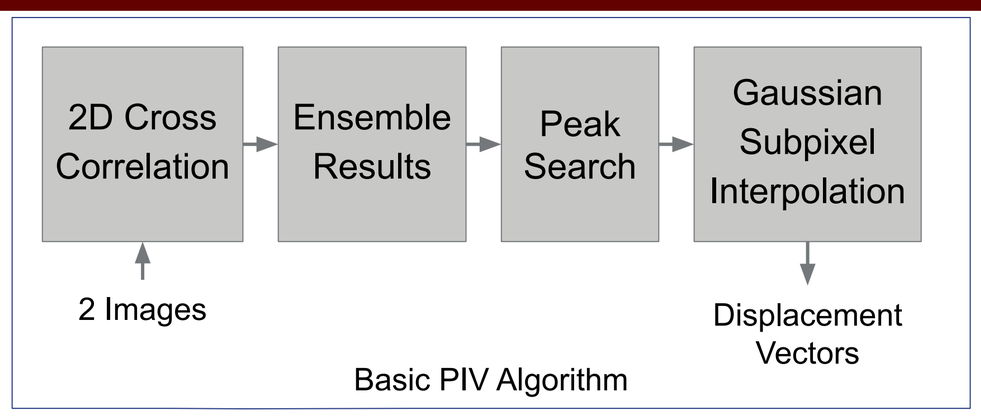
Problem

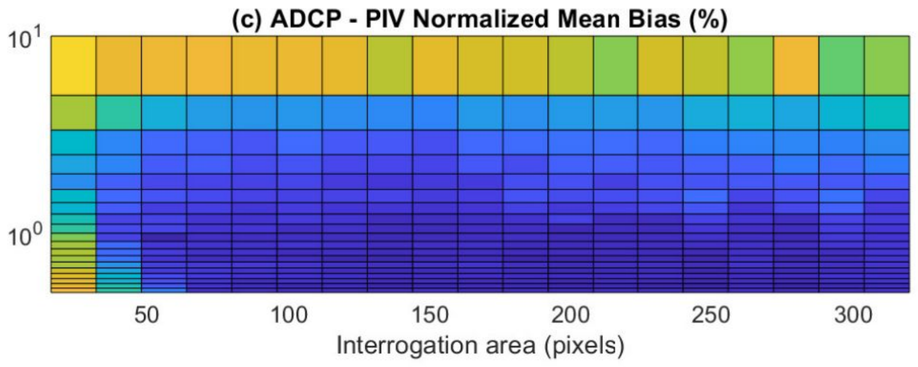
- Stakeholder wants to install stream flow monitoring device onto bridge or UAS
- PIV algorithm is used to analyze stream flow as a post processing method now
- No system can perform PIV in real-time on the remotely deployed sensors
- The stream flow monitoring system should survive for months to years

Goals

- Create an embedded version of the PIV algorithm targeted to run in real-time on embedded systems
  - Target the CommonSense Platform
  - Should agree with the result of existing software
- Optimize algorithm & software architecture
  - Metrics: energy, computation time, accuracy
- Start early system design of final product

Proposed Algorithm

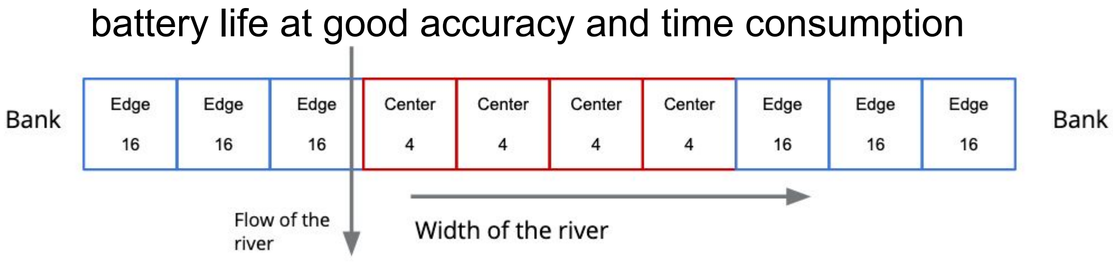




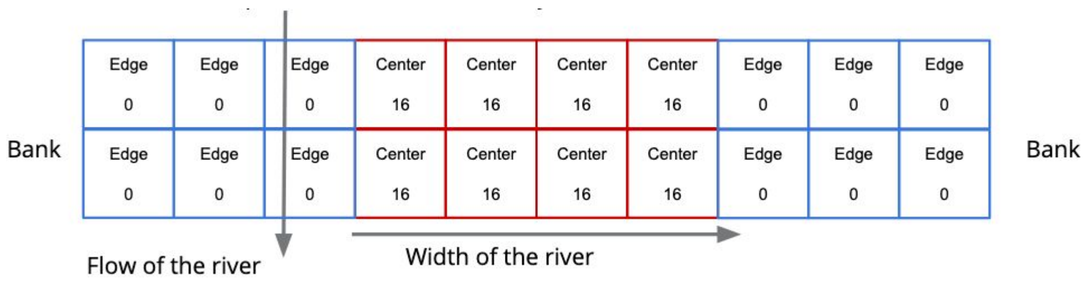
64x64 pixel image size is minimum size to achieve good accuracy

PIV Area (Length and Breadth in pixels)		Total # Ensemble pairs	Total time consumption (in sec)
1580	64	224	44.94261333
1000	64	140	28.08913333
64	64	12	2.40764
1580	128	432	86.67504
1000	128	280	56.17826667
64	128	24	4.81528

Ensembling consumes most time and power. Optimum values of ensemble pair is to be chosen to obtain best battery life at good accuracy and time consumption



Velocity Mode - Higher accuracy velocity in more turbulent of the stream but takes longer

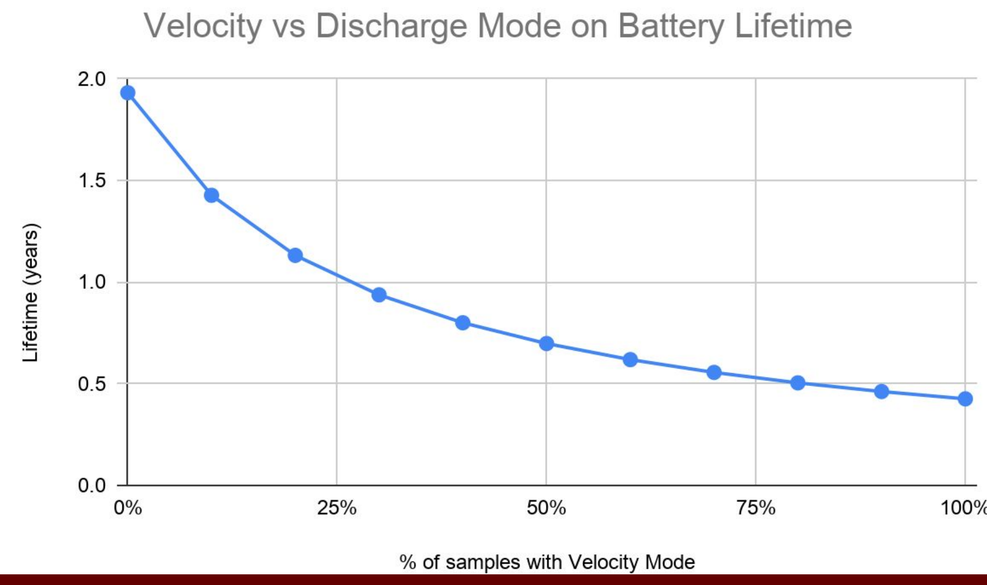


Discharge Mode - Focus PIV near the middle of the stream for high accuracy velocity vector discharge measurement

Energy Analysis

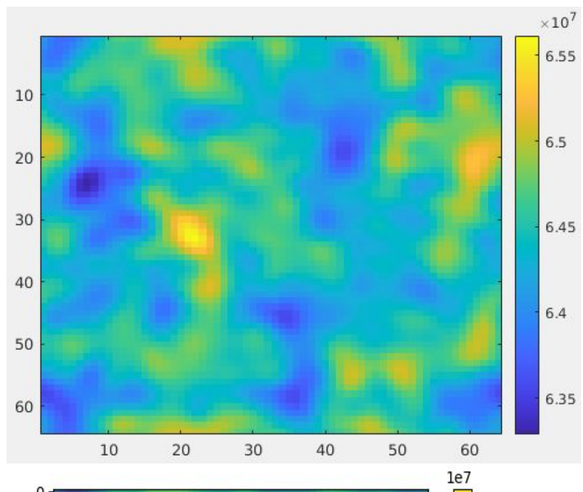
			% ON hour	mAh
Processor	Computing (mA)	50.808	10.07%	5.1181642
Contribution to Power	standby (uA)	18	0.00%	0
99.55%	hibernate(uA)	4	89.93%	0.00359
Radio	Receive Mode (mA)	10.8	0.01%	0.0012
Contribution to Power	Transmit Mode (mA)	29	0.08%	0.0218080
0.45%	Sleep Mode (uA)	0.2	99.91%	0.0001998
			Total (mAh)	5.1449620
			Years of Life	0.5325066

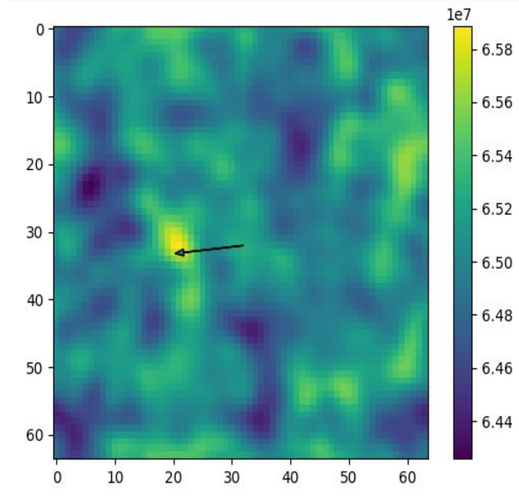
- 8 samples/hour on 1580x64 image -> 0.53 years of life
- Use discharge mode (calculates velocity with less interrogation areas) to quintuple the lifespan



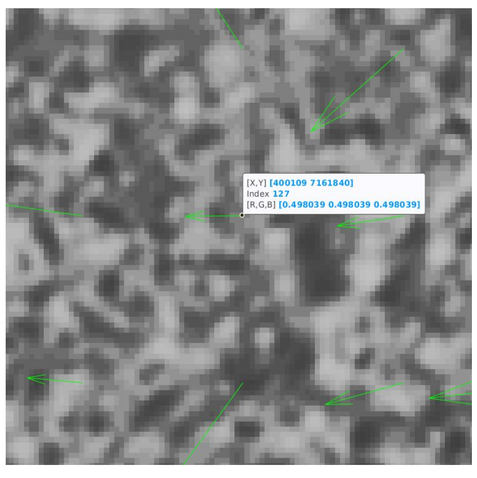
Results

PIVLab (Matlab)





PIVLab displacement vector
Magnitude 1.6834(m/s)
Direction: (-1, -0.0108)



Our implementation
Magnitude: 10.273 (PIXELS/s = 1.54m/s) Direction: (-1, 0.1007)
Note the change in sign, the MatLab output is reoriented 180deg such that North is up, opposite of our implementation

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