

Online Structural State-Estimation in Extreme Dynamic Environments

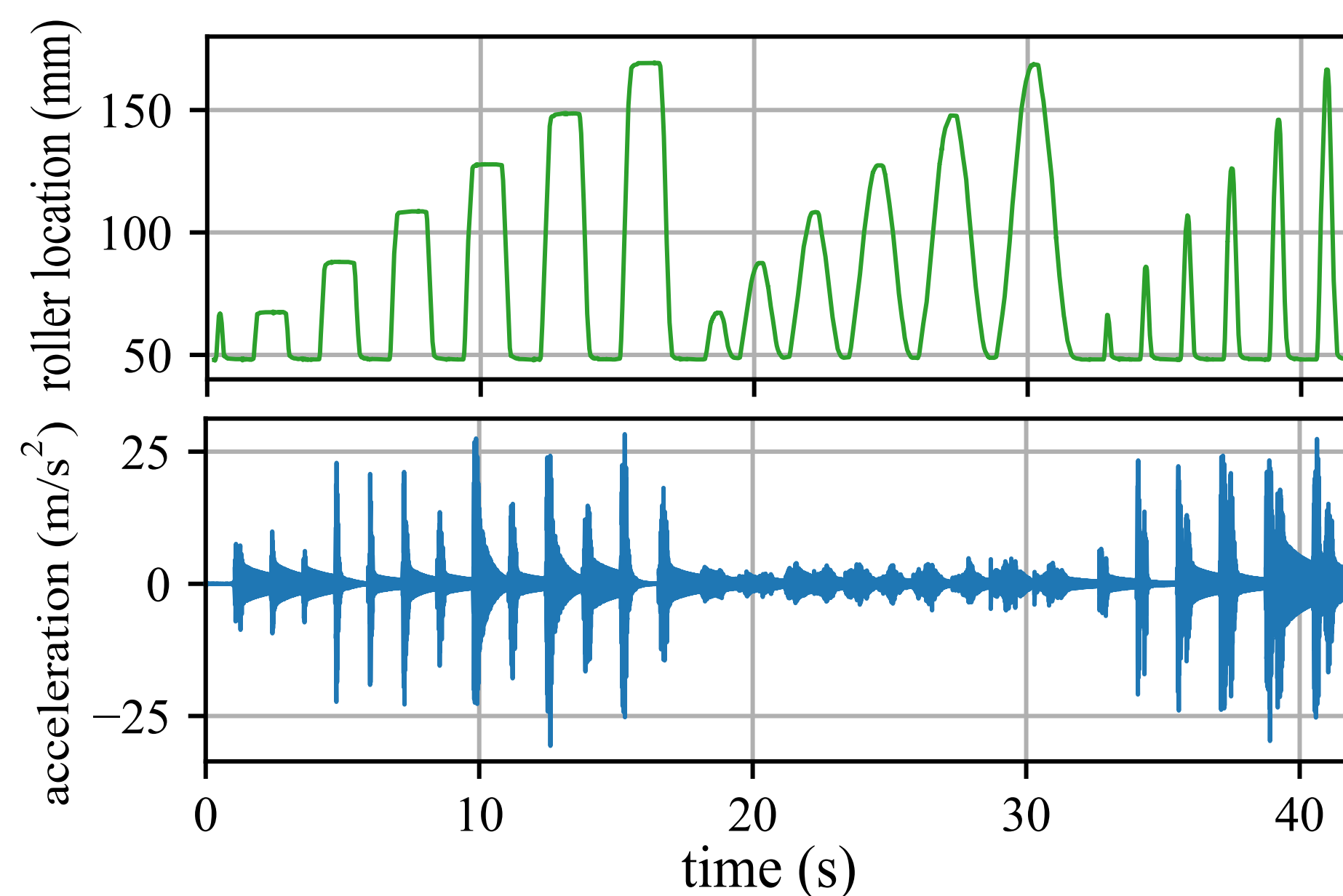
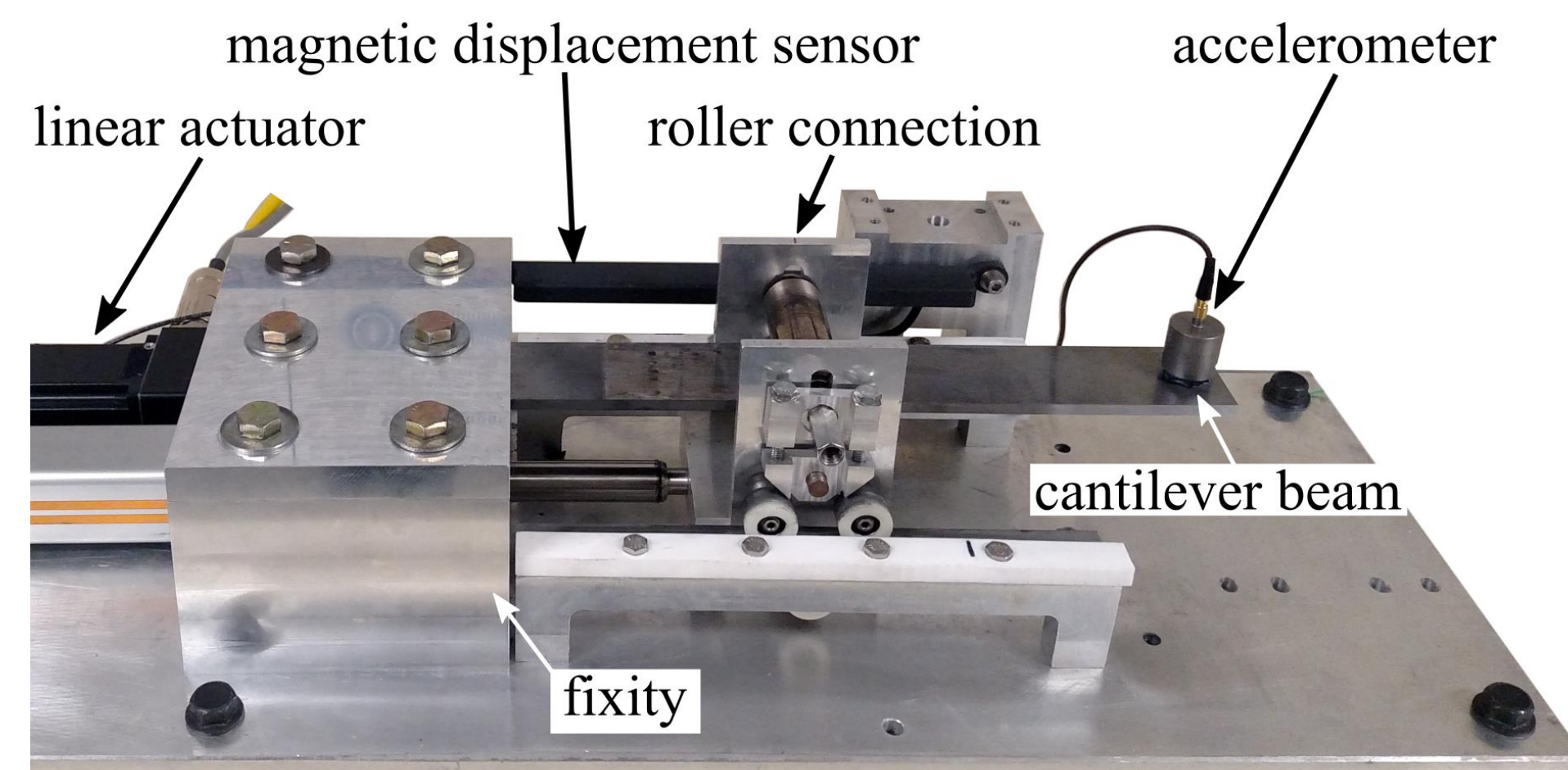
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Introduction

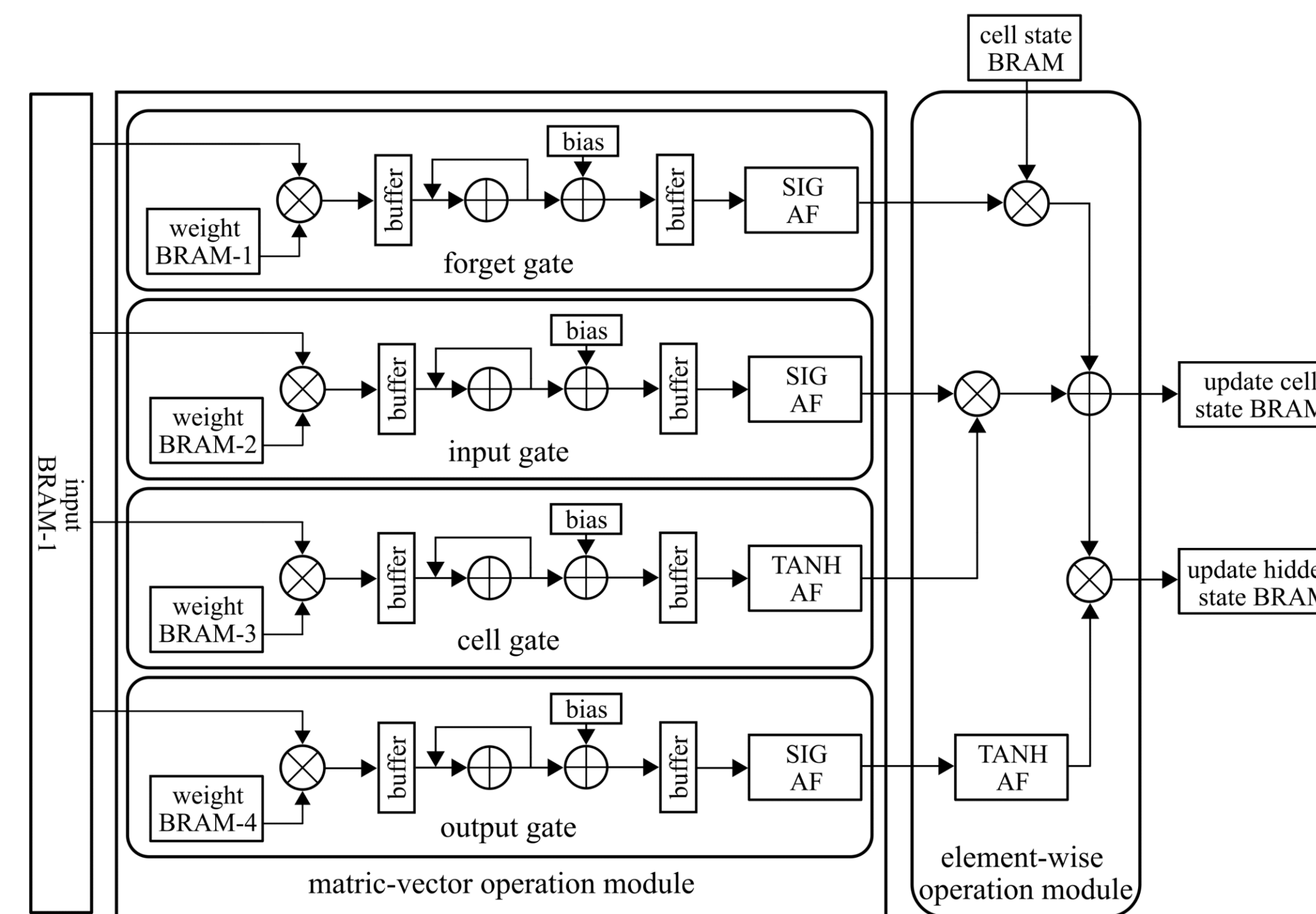
- High-rate dynamic structures are subjected to impact loading with accelerations greater than 100 g over time periods of less than 100 milliseconds.
- Goal: create a data-driven model capable of producing low-latency state prediction from a time-domain signal.

DROPBEAR Testbed

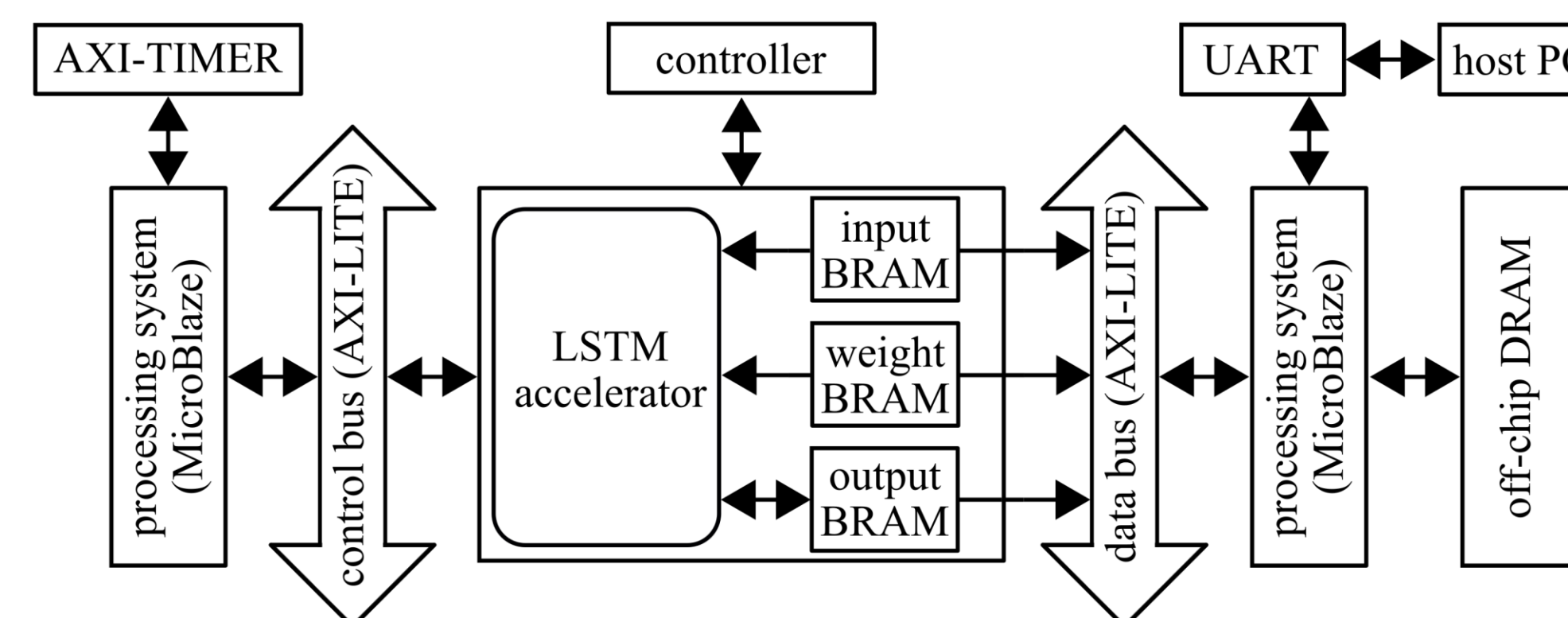


Model Development

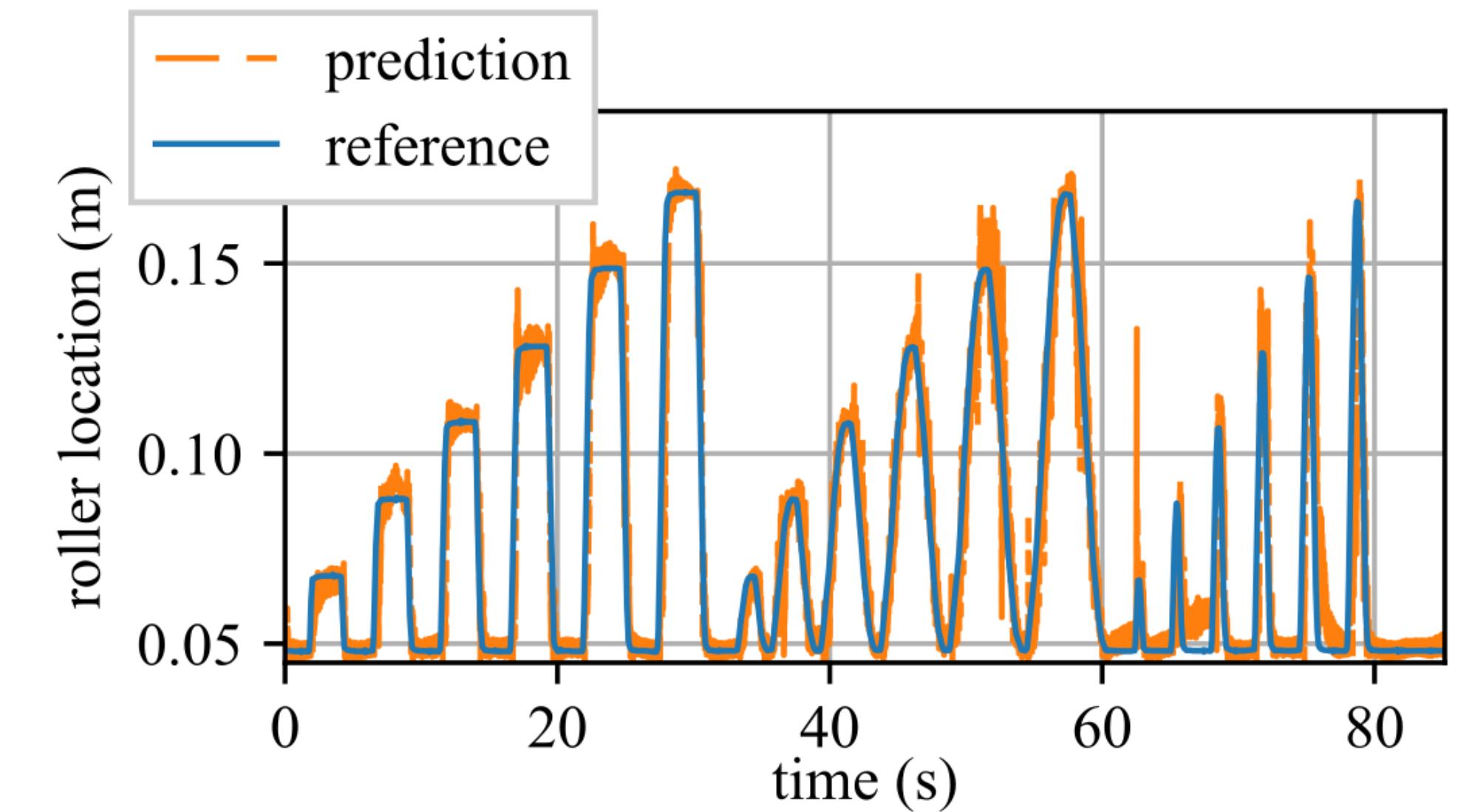
- Long short-term memory (LSTM) is a commonly used recurrent neural network architecture.



- LSTM deployed as a hardware accelerator in a field programmable gate array (FPGA) in both a 16-bit fixed point and a 32-bit float version.



Results



- 16-bit fixed point model performance,
 - SNR_{dB} of 19.54 dB.
 - RMSE of 9.1 mm.
 - Time step of 16.7 μs.
 - Standard deviation: 0.0509 μs.
 - 50X speed up over RTOS.
- 32-bit floating point model performance:
 - SNR_{dB} of 22.02 dB.
 - RMSE of 6.8 mm.
 - Time step of 64.9 μs.
 - Standard deviation: 0.0379 μs.
 - 12X speed up over RTOS.
- Both implementations consume less than 10% of FPGA resources (Xilinx Virtex 7 - VC707) .

Model	Freq. (MHz)	Data Precision	LUT	FF	BRAM 36 k	DSP
16, 15, 15, 15, 1	200	32bit Float	91611	107964	211	142
16, 15, 15, 15, 1	200	16bit Fixed	126633	109186	229	212