# Latency Part 1

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I attended REK Robot Kombat in SF on Sept 24, 2025 with teleoperators using VR headsets and handheld devices to control humanoid Unitree H1 fighter punching. Footwork and orientation appeared to be independent of operator control and presumed policy based. There was pre-fight testing by REK. I did a frame by frame analysis of pre-fight testing from my iphone video recording to identify frame instances for teleoperator load, robot load, teleoperator punch, robot punch. There are total 135 frames over 4.5 seconds with each frame representing 33.3ms.
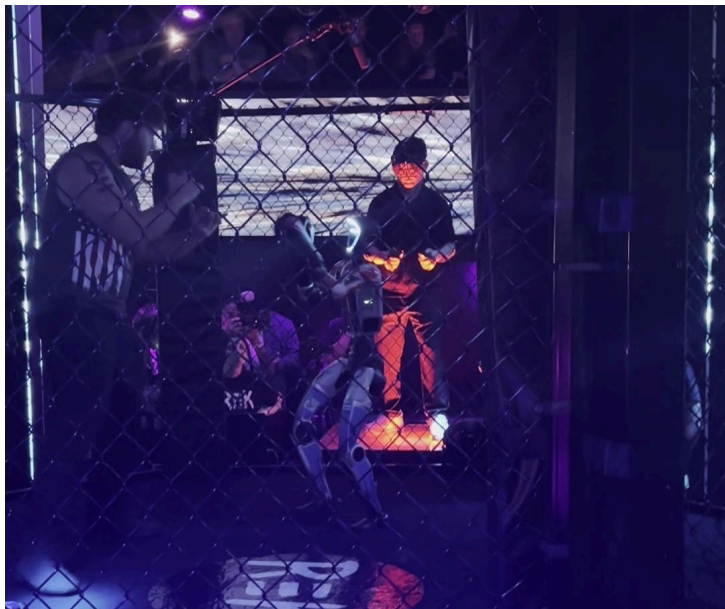
Frame range estimates are:

Image sequences 1 and 2 for operator load initiation: 110-115,
Image sequences 1 and 2 for operator punch initiation: 115-120,
Image sequence 3 for robot load initiation: 125-130, and
Image sequence 3 for robot punch initiation: 130-135.

Derived min and max latencies are:

Minimum load latency: 333.3ms
-Frame 115 vs frame 125 (10 x 33.3ms)
Maximum load latency: 666.6ms

-Frame 110 vs frame 130 (20 x 33.3ms)
Minimum punch latency: <u>166.5ms</u>
-Frame 125 vs frame 130 (5 x 33.3ms)
Maximum punch latency: <u>333.3ms</u>
-Frame 120 vs frame 130 (10 x 33.3ms)
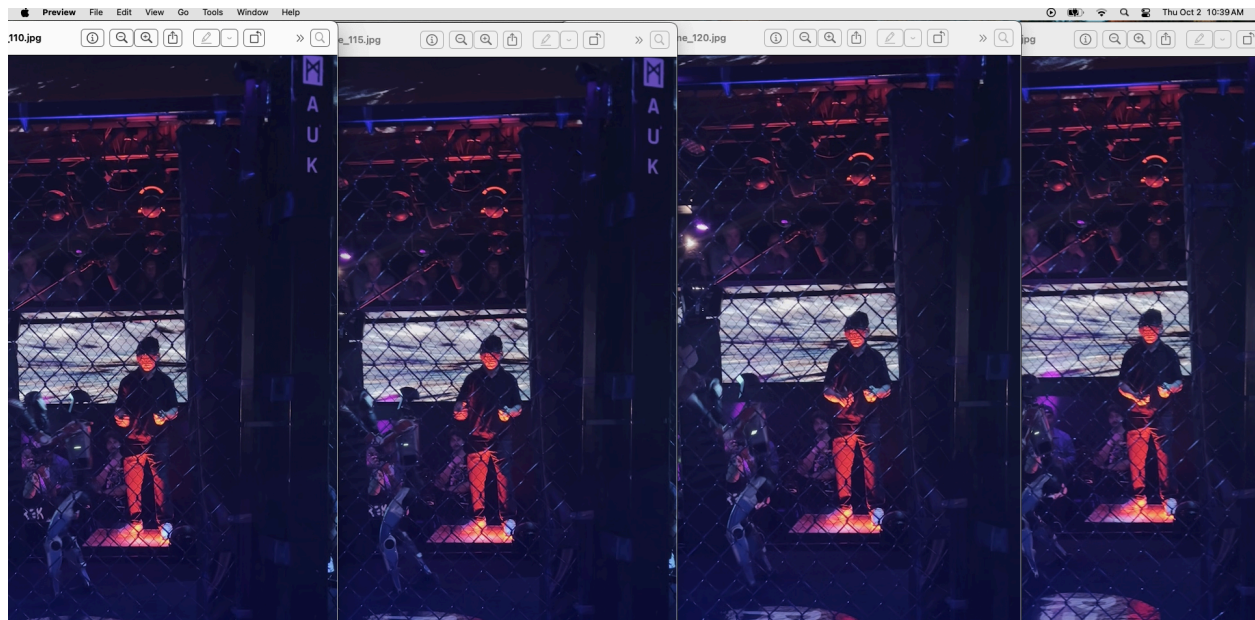
Image sequence 1:
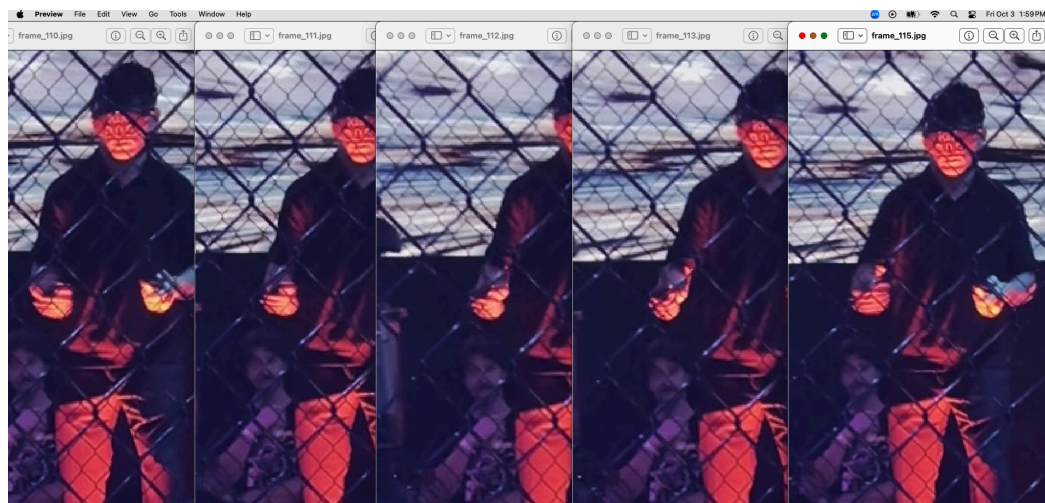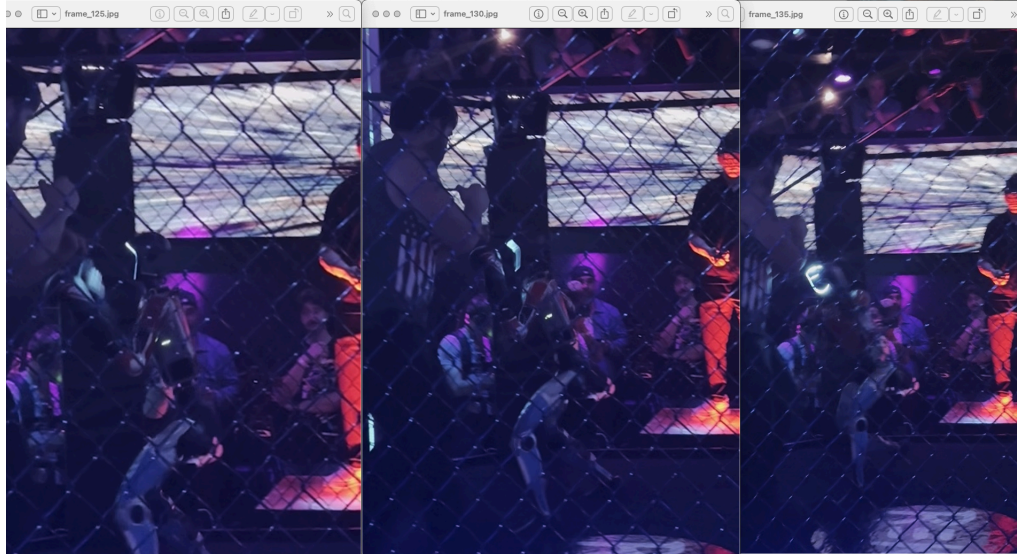

Image sequence 2:

Image sequence 3:

Human boxing operates within extremely tight temporal constraints. The execution of a punch has been estimated in the range of 150-200 milliseconds from initiation to impact[1]. Human boxer defensive response components include visual perception, cognitive decision, motor control latency, and physical execution of defense movement.

For humanoid sparring VR-based teleoperation introduces latency across multiple system components that together create significant operational delays. These include robot camera capture, video encoding, transmission (video stream), video decoding, headset processing, VR display refresh, human visual perception (of the incoming strike), operator reaction-decision, controller input capture, transmission, and then robot actuator response. Wireless rather than wired increases latency.

For humanoid sparring to replicate temporal aspects of human boxing, latency time must be reduced to a fraction of the punch time. Is that latency time achievable with wireless teleoperation, is it achievable with wired teleoperation?

[1]https://boxingscience.co.uk/science-behind-punch/