low-cost telemanipulators enabling telework for manual labor

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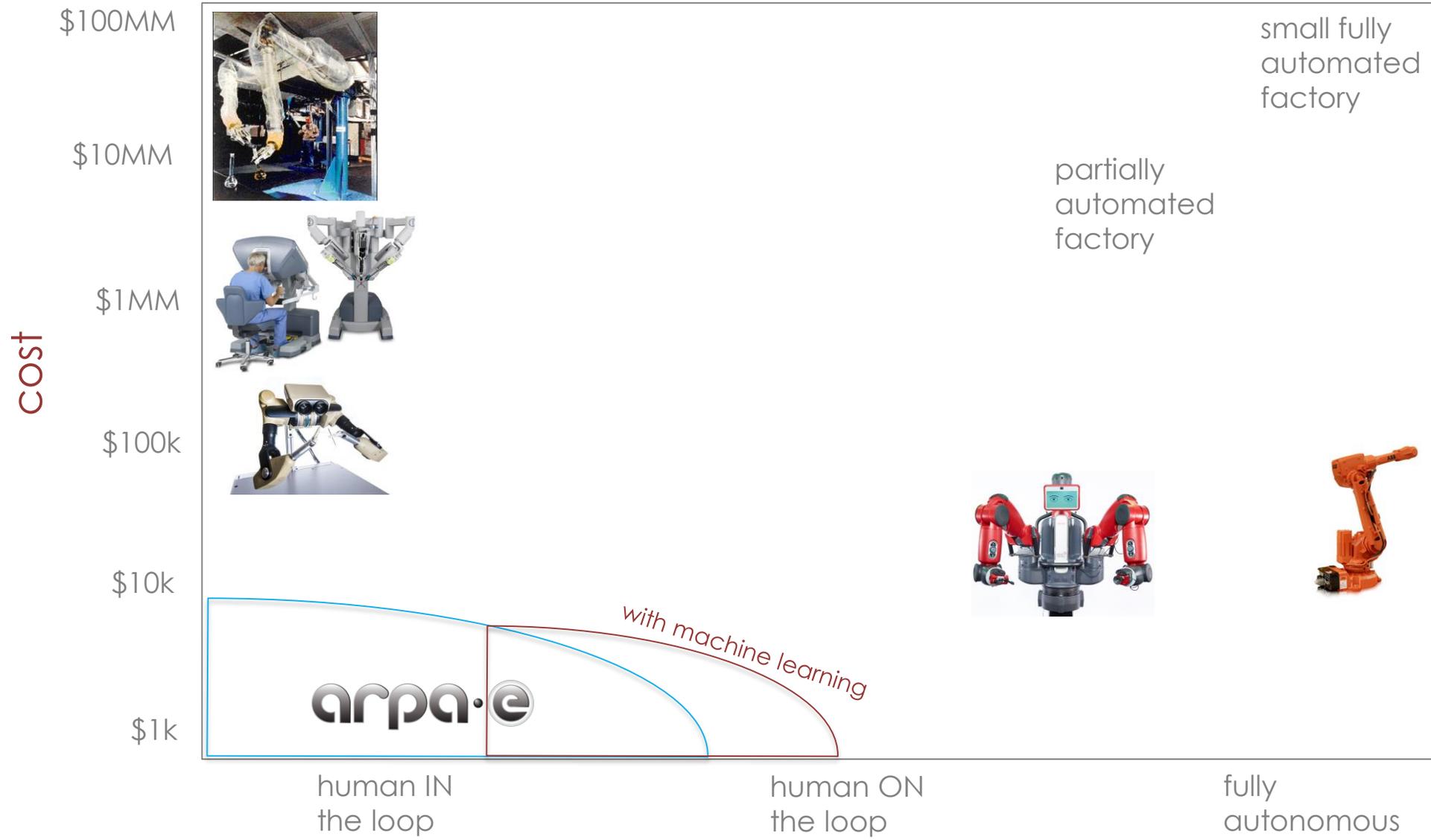
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arpa·e

robotic manipulation technical space

cost

$100MM

$10MM

$1MM

$100k

$10k

$1k

small fully automated factory

partially automated factory

with machine learning

arpa·e

human IN the loop

human ON the loop

fully autonomous

autonomy

3rd axis: capability

we must increase capability/cost

human anthropometry:

. 7 DOF upper arm (through wrist)

. 21 DOF per hand

. 1950-8500 degrees/second[1,2,3]

. max payload >30 pounds

. waterproof, dustproof

. distributed array of sensors (thousands)

. response latencies of 2-10 ms

. local control through distributed neural network

. fine-tuned feedback control through vision

. runs on approximately 100 watts

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vs. robots:
. limbs cost $500-5000 per DOF
. shadow hand (24 DOF) and
. JHUAPL/HDT Robotics MPL hand (10 DOF)
. most not waterproof, dustproof

. 10s to 100s of sensors per limb
. response latencies of >20 ms
. planned paths and limited close loop
. can draw 10s to 1000s of watts

we must develop new controls for teleoperation

focus on capability
. audiovisual immersion?
. haptics?
. sliding autonomy
. comfortable to use
. intuitive, fast learning curve

level of autonomy
. path planning
. grasping
. repeat functions
. safety limits
. machine learning

mode of control
. imitative/master slave
. keyboard/mouse
. mocap
. handheld controller
. voice
. direct neural control
. multi-robot

cost of controller is a concern.

program concept: telelabor with low cost, high quality telemanipulation

mission: create ultra low cost human-operated manipulators that allow economically performing labor at a distance.

track 1: low cost, intuitive human robot interfaces for remote operation ($20MM, phased, ~20 teams)

track 2: low cost arms and end effectors with focus on actuation ($10MM, ~4 teams)

track 3: integration of track 1 and 2 ($5MM, telelabor prize competition)

teams
mechanical engineers
computer vision
electrical engineers
robot companies
human factors

program metrics
cost
payload
capability
operator enjoyment
cognitive loading

potential program outcome: we invent "telelabor": a new class of teleoperated manipulators that allow people to physically interact with the world at a distance for generic tasks, potentially changing labor as we understand it today.