Skills vs. Unified Robotics Curriculum — Comparison

This table maps each skill from skills.md to the corresponding area(s) in the unified robotics curriculum, noting which pillar, specialization, or foundation covers it and any gaps.

Legend

Symbol	Meaning
✅	Directly covered by curriculum coursework
⚠️	Partially covered or covered as a subtopic
❌	Not explicitly covered in curriculum

1. Software Skills

#	Skill	Cov.	Curriculum Section	Notes
1.1	Localization	✅	Pillar 2: Sensing & Perception — Robot Perception; Spec 3.2: SLAM & Localization	Core topic in probabilistic robotics and SLAM courses (CMU 16-833, UMich ROB 530)
1.2	Writing algorithms for localization	✅	Pillar 2: Robot Perception; Pillar 3: Probabilistic Robotics	Bayesian filtering, particle filters, EKF covered across all 10 programs
1.3	Training using a simulation	✅	Pillar 5: Robot Systems Integration (Gazebo, MuJoCo, Isaac Sim); Spec 3.3: Robot Learning; Spec 3.8: Simulation	Sim-to-real transfer, reinforcement learning in simulation covered in robot learning courses
1.4	State machines	⚠️	Pillar 3: Planning & AI; Pillar 5: Robot Systems Integration	Covered as a subtopic in planning/AI and ROS-based systems courses; not a standalone course
1.5	Behavior trees	⚠️	Pillar 3: Planning & AI	Emerging topic in task planning courses; less formalized than state machines in curricula
1.6	Using state machines and behavior trees to switch between custom controllers	⚠️	Pillar 3: Planning & AI; Pillar 4: Control Systems	Covered at the intersection of planning and control integration; appears in capstone/systems courses
1.7	Creating digital environments	✅	Pillar 5: Simulation environments (Gazebo, Isaac Sim, MuJoCo); Spec 3.8: Simulation & Computational Methods	Simulation environment creation covered in systems integration and sim-to-real courses
1.8	Programming environment and IRL mapping	✅	Pillar 2: SLAM & Perception; Pillar 5: ROS/simulation	Digital twin creation and real-world mapping covered in perception and systems courses
1.9	Writing custom algorithms	✅	All Pillars	Fundamental to every course — algorithm design pervades the entire curriculum

#	Skill	Cov.	Curriculum Section	Notes
1.10	Computer vision (OpenCV)	✅	Pillar 2: Computer Vision	Core pillar course at all 10 universities; OpenCV is a standard tool
1.11	Having speed and torque version of controls	✅	Pillar 4: Feedback Control Systems; Pillar 5: Mechatronics	Motor control (speed/torque modes) covered in control and mechatronics courses
1.12	Sensor filtering	✅	Pillar 2: Robot Perception; Pillar 4: Optimal Control & Estimation; Foundation 1.2: Signals & Systems	Kalman filtering, particle filters, signal processing covered extensively
1.13	OpenCV prediction	✅	Pillar 2: Computer Vision; Spec 3.3: Deep Learning	Object detection, tracking, and prediction using vision libraries covered in CV and deep learning courses

2. Hardware Skills

#	Skill	Cov.	Curriculum Section	Notes
2.1	Depth and RGB Camera	✅	Pillar 2: Sensor Systems & Instrumentation; Pillar 2: Computer Vision	Camera models, calibration, stereo vision, depth estimation are core perception topics
2.2	Generate collision voxels	⚠️	Pillar 3: Motion Planning; Spec 3.8: Robot Dynamics & Simulation	Voxel-based collision representation is a subtopic in motion planning and simulation courses
2.3	ROS visualization	✅	Pillar 5: Robot Operating System (ROS) — RViz	ROS visualization tools (RViz) explicitly covered in systems integration courses
2.4	IRL sensors into digital representations	✅	Pillar 2: Sensor Systems & Instrumentation; Pillar 5: ROS	Sensor interfacing, data acquisition, and digital representation are core systems topics

3. Electrical Skills

#	Skill	Cov.	Curriculum Section	Notes
3.1	Electrical FW (firmware)	⚠️	Pillar 5: Electronics for Robotics; Pillar 5: Mechatronics	Embedded firmware covered in mechatronics and electronics courses but not always deeply; more EE-focused programs (MIT 2.678, CMU 16-220) go deeper

4. Software Tools

#	Tool	Cov.	Curriculum Section	Notes
4.1	Jetson (NVIDIA)	⚠️	Pillar 5: Robot Systems Integration	Used in lab settings at several programs but not a formal course topic; appears in capstone/project courses
4.2	Simulink	✅	Pillar 4: Control Systems; Foundation 1.2: Signals & Systems	Standard tool in control systems courses (MIT 2.004, UMich ROB 301, GT ECE 6550)
4.3	Gazebo	✅	Pillar 5: Simulation environments	Explicitly listed as a key simulation tool in systems integration courses
4.4	Isaac Sim	✅	Pillar 5: Simulation environments; Spec 3.3: Robot Learning	Explicitly listed; used for sim-to-real in robot learning courses
4.5	ROS	✅	Pillar 5: Robot Operating System (ROS)	Core tool across all 10 programs; dedicated coverage in systems courses
4.6	OpenCV	✅	Pillar 2: Computer Vision	Standard library used in all computer vision courses
4.7	PyTorch (algorithms and training)	✅	Spec 3.3: Deep Learning, Reinforcement Learning; Pillar 2: Deep learning for perception	Primary framework for deep learning and robot learning courses
4.8	RViz	✅	Pillar 5: Robot Operating System (ROS)	Standard ROS visualization tool covered in systems integration courses

5. Communication Systems

#	Skill	Cov.	Curriculum Section	Notes
5.1	CAN bus	⚠️	Pillar 5: Mechatronics; Pillar 5: Electronics for Robotics	Covered as a subtopic in mechatronics and embedded systems courses; not a standalone course
5.2	RS232	⚠️	Pillar 5: Mechatronics — Sensor interfacing (UART)	RS232/UART covered as part of serial communication in mechatronics labs
5.3	EtherCAT	❌	—	Industrial fieldbus protocol; not typically covered in academic robotics curricula. More common in industrial automation and industry training
5.4	Drivers	⚠️	Pillar 5: Electronics for Robotics; Foundation 1.3: Computer Systems	Motor drivers covered in electronics courses; software drivers touched in computer systems courses

6. Engineering Skills

#	Skill	Cov.	Curriculum Section	Notes
6.1	Simulating solid systems	✅	Spec 3.8: Robot Dynamics & Simulation; Spec 3.8: Computational Design	Rigid body simulation, FEA covered in dynamics and computational courses
6.2	Simulating hydraulic systems	❌	—	Not typically part of robotics curricula; more common in ME fluid mechanics / fluid power courses. Some mechatronics courses may touch on hydraulic actuators
6.3	System modeling and control	✅	Pillar 4: Control Systems (all 4 courses); Foundation 1.2: Signals & Systems	Central to the entire control systems pillar; covered at all 10 universities
6.4	Differential equations	✅	Foundation 1.1: Differential Equations	Prerequisite course required at all 10 programs
6.5	Linear algebra	✅	Foundation 1.1: Linear Algebra	Prerequisite course required at all 10 programs
6.6	Dynamics	✅	Pillar 1: Dynamics of Mechanical Systems; Foundation 1.2: Statics & Dynamics	Core prerequisite and pillar topic at all 10 programs
6.7	Mechanics	✅	Pillar 1: Robot Mechanics; Foundation 1.2: Classical Mechanics, Statics & Dynamics	Foundational topic spanning physics prerequisites and robotics core
6.8	Fatigue	❌	—	Materials science / mechanical engineering topic; not covered in robotics-specific curricula. Would be in a traditional ME materials course (e.g., MIT 2.002)

Summary

Category	Total Skills	✅ Covered	⚠️ Partial	❌ Not Covered
1. SoftwareSkills	13	10	3	0
2. HardwareSkills	4	3	1	0
3. ElectricalSkills	1	0	1	0

Category	Total Skills	✅ Covered	⚠️ Partial	❌ Not Covered
4. SoftwareTools	8	7	1	0
5. CommunicationSystems	4	0	3	1

Category	Total Skills	✅ Covered	⚠️ Partial	❌ Not Covered
6. Engineering Skills	8	6	0	2
Total	**38**	**26 (68%)**	**9 (24%)**	**3 (8%)**

Key Gaps in the Curriculum

The three skills **not covered** by the unified robotics curriculum are:

1. **EtherCAT (5.3)** — Industrial real-time fieldbus protocol used in automation. Academic programs focus on general communication protocols (UART, SPI, I2C) rather than industrial-specific standards.
2. **Simulating hydraulic systems (6.2)** — Covered in traditional Mechanical Engineering fluid power courses, not in robotics-specific curricula. Relevant for heavy-duty industrial and construction robots.
3. **Fatigue (6.8)** — A materials science / structural engineering topic covered in ME materials courses (e.g., MIT 2.002 Mechanics and Materials II) but outside the scope of robotics programs.

Skills Well-Aligned with Curriculum

The strongest alignment is in: - **Computer vision, localization, and perception** — Core pillar at all universities - **Control systems and system modeling** — Universal coverage - **ROS, Gazebo, simulation tools** — Explicit curriculum content - **Math foundations (linear algebra, diff. eq., dynamics)** — Required prerequisites everywhere