• actuation method, hardware control labels

label	contents
a_1	pneumatic
a_2	hydraulic
<i>a</i> ₃	motor
<i>a</i> ₄	electro + hydraulic
a_5	pneumatic + motor
<i>a</i> ₆	cable driven

• hardware control labels

label	contents
hc ₁	remote + operator
hc_2	automatic
hc3	human-robot + collaboration
hc4	manual

• application labels

label	contents	label	contents	label	contents
A_1	road construction	A_{22}	masonry construction	A_{43}	joint filling
A_2	titling placing	A_{23}	on-site rescue	A_{44}	panel installation
A_3	building service	A_{24}	machinery path management	A_{45}	cleaning
A_4	ferromagnetic surface construction	A_{25}	grasp soft objects	A_{46}	machinery mapping
A_5	earthmoving construction	A_{26}	remote operating machines	A_{47}	mining
A_6	building inspection	A_{27}	airforce construction	A_{48}	logistics
A_7	excavation	A_{28}	ceiling construction	A_{49}	transmission tower construction
A_8	steel construction	A_{29}	material, sorting, delivery, distribution	A_{50}	operation simulation
A_9	tunnel construction	A_{30}	Mars/Lunar construction	A_{51}	pose estimation
A_{10}	glass installation	A_{31}	slab finishing	A_{52}	measurement
A_{11}	wall construction	A_{32}	machinery navigation	A_{53}	highway construction
A_{12}	bridge construction	A_{33}	reduce lifting workload	A_{54}	arc welding
A_{13}	construction monitoring	A_{34}	components assemble	A_{55}	underwater work
A_{14}	equipment positioning	A_{35}	construction activity evaluation	A_{56}	remote construction
A_{15}	building quality assessment	A_{36}	diagnosis detection	A_{57}	improve home living environment
A_{16}	concrete printing	A_{37}	timer construction	A_{58}	finishing
A_{17}	high rise building construction	A_{38}	marking	A_{59}	object recognition
A_{18}	large-scale building construction	A_{39}	hazard detection	A_{60}	drilling
A_{19}	building maintenance	A_{40}	harbour construction	A_{61}	scaffolding work
A_{20}	spraying	A_{41}	waste collection	A_{62}	fire curtain testing
A_{21}	pipe construction	A_{42}	disaster restoration	A_{63}	contour crafting

• control algorithm labels

performance test, evaluation cator dynamic model cator PTP control cator P	label	contents	label	contents
asy malytical model asy Actuator-level languages asy estimate ego-position asy terrative algorithms + regression model asy pure-pursuit method asy path-planning path-planning path-planning asy pure-pursuit method asy keadedical method asy performance test, evaluation asy Kalman Filter Algorithm asy performance test, evaluation asy Msc. Adams and Matlab/Simulink program dynamic model asy performance test, evaluation asy Msc. Adams and Matlab/Simulink program dynamic model asy performance test, evaluation asy PTP control asy prodition asy Particle Swarm Optimization (PSO) algorith asy prodition teaching system asy	ca ₁	SFT algorithm, NNG algorithm	ca ₆₁	pixels regression
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ar Dijkstra's algorithm cate Kalman Filter Algorithm ars tractive thrust cates Msc. Adams and Matlab/Simulink program art performance test, evaluation cates Msc. Adams and Matlab/Simulink program draft beuristic cates dynamic model art Description Cates PIP control draft Mesh Mould cates PIP control draft DNDT-method cates PRID art Control travel speed cates IFC + BIM art District traction cates IFC + BIM art District traction cates IFC + BIM art LPA* algorithm digital signal processing (DSP) controller art dathitance control cates torque measure methods art cates RBF-PID Control augmented reality techniques (AR) art vision based gesture estimation, CARLOS cates RBF-PID Control art cates Machine Interfaces (IMUS) cates art <td>ca₅</td> <td>PI controller + active control algorithm</td> <td>ca₆₅</td> <td>path-planning</td>	ca ₅	PI controller + active control algorithm	ca ₆₅	path-planning
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heuristic and heuristic and Mesh Mould and TCP control TCP control	ca ₈	tractive thrust	ca ₆₈	Msc. Adams and Matlab/Simulink programs
Mesh Mould Auti inear interpolation algorithm-TP language Auti inear interpolation (PSO) algorithm Auti inearing (AR) Auti inearing (DSO)	ca ₉	performance test, evaluation	ca ₆₉	dynamic model
catz inear interpolation algorithm-TP language catz Particle Swarm Optimization (PSO) algorith catz NDT-method catz RFID catz control travel speed catz	ca ₁₀	heuristic	ca ₇₀	PTP control
adjj NDT-method cdjk RFID adjk control travel speed cdjk IFC + BIM adjj off-line teaching system cdjk LPA* algorithm adjj user datagram protocol (UDP) cdjk torque measure methods adjj admittance control cdjk torque measure methods adjj simplified error analysis model cdjk augmented reality techniques (AR) adjj simplified error analysis model cdjk predictive force method adjj simplified error analysis model cdjk predictive force method adjj simplified error analysis model cdjk predictive force method adjj potmizzing welding sequence cdjk predictive force method adjj potmizzing welding sequence cdjk predictive force method adjj potmizzing welding sequence cdjk finite element method adjj power line communication net cdjk force feedback control adjj power line communication net cdjk Force feedback control adjj fusion fuzzy, fuzzy logic, fuzzy set theory cdjk <	ca ₁₁	Mesh Mould	ca71	TCP control
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ca34 Anderson Passive control theory ca95 PLC ca35 BIM, prepare the trajectories ca96 real time navigation ca36 PID position control ca97 cost optimization ca37 intelligent beacon ca98 tree-Based algorithm ca38 least squares algorithm ca99 dedicated smart sensors	ca ₃₂		CA93	
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ca37intelligent beaconca98tree-Based algorithmca38least squares algorithmca99dedicated smart sensors	ca35	BIM, prepare the trajectories	ca ₉₆	real time navigation
ca ₃₈ least squares algorithm ca ₉₉ dedicated smart sensors	ca ₃₆	PID position control	ca ₉₇	cost optimization
	са37	intelligent beacon	CA98	tree-Based algorithm
ca ₃₉ voltage response ca ₁₀₀ markov chains	ca ₃₈	least squares algorithm	ca ₉₉	dedicated smart sensors
	са39	voltage response	ca ₁₀₀	markov chains

CA40	collision avoidance algorithms, feed forward control algorithms	ca ₁₀₁	robust algorithm
CA41	timing algorithm	CA102	MPEG algorithm + pair-wise alignment algorithm + Minimum V variance Matching (MVM) Algorithm
ca ₄₂	HyperCard program	ca ₁₀₃	motion planning
CA43	inverse kinematic and dynamic models	CA104	integral monitoring system
CA44	3D printer control	ca ₁₀₅	A* algorithm, A-star
CA45	discrete event simulation model	ca ₁₀₆	point cloud data control
<i>са</i> ₄₆	embedded, embedding, controller	ca ₁₀₇	random walk algorithm
CA47	UML state charts and capsules	CA108	positioning system
CA48	Hierarchical planning	ca ₁₀₉	stereovision method
CA49	genetic algorithms (GA)	ca ₁₁₀	Iterative Closest Point (ICP) algorithm
CA 50	kinematic connection	ca ₁₁₁	measures vector value of vertical lifting
ca ₅₁	Iterative Inverse Perspective Matching algorithm	ca ₁₁₂	Ubiquitous Sensor Network
ca52	longest common subsequence (LCS)	ca ₁₁₃	velocity control
ca ₅₃	forward and inverse geometric model	ca ₁₁₄	behaviour-based system
CA54	inverse position equation	ca ₁₁₅	self-positioning algorithm
ca55	teaching robots' specific skills	ca ₁₁₆	segmentation approach
ca ₅₆	best-fit algorithms	ca ₁₁₇	automatic battery replacement
CA57	C-K Theory	CA118	SLAM
CA 58	soft additive fabrication	CA119	error modification
CA 59	primitive static states	ca ₁₂₀	distance estimation
ca ₆₀	workflow method		
<i>ca</i> 73		neural	omputer vision, Deep Reinforcement learning, networks, RRT algorithm, LNSNet network, glass Networks, CV algorithm. open CV.

• sensory system labels

label	contents	label	contents
S1	laser + ultrasonic + CCD camera	\$80	infrared + camera
\$2	camera + pressure sensor + force sensor + magnetostriction sensor + tactile sensor, gyro	\$81	angle sensor
S3	position sensor + camera	\$82	laser + lidar
S4	image sonars + camera + LBL, gyro	S83	IMU + laser
\$5	pressure sensor + tactile sensor		GPS + lidar + camera + angle sensors + distance sensors + force sensor + depth sensor + radar, ultrasonic sensors + IMU
S6	torque/force sensor + force sensor	S85	pressure sensor + speed sensor + proximity sensors
\$7	camera	S86	range sensor + displacement sensor + GPS
S8	pressure sensor	S87	range sensors + distance sensor
S 9	visual sensor	S88	pressure sensors + laser sensor
\$10	ultrasonic	\$89	liquid based sensor
S ₁₁	visual sensor + touch sensor + optical detector + arc weaving sensor	\$90	IR sensor + F/T sensor + acceleration sensor
S ₁₂	tactile sensing system + welding sensor	S91	elasto-magnetic (E/M) sensor

\$13	arc sensor + laser	S92	robust sensor + pressure sensors + force
S14	laser	S93	LPG sensor + a smoke sensor
S ₁₅	laser + torch senser	S94	LTK + GPS + pseudofiles + laser + NLS
S16	CCD camera + stereo sensor	S95	sonar system
\$17	LIDAR sensors + IMU + Kinetic	S96	camera + accelerometers
S ₁₈	various sensors + sensor system	S97	front rear sensors + wireless camera
318	3D laser + camera + torch sensor +	39/	
\$19	galvanometer scanner	S98	analogy voltage sensor + laser profile probe
\$ <u>20</u>	vacuum sensor + air pressure sensor + position sensor + camera	S99	orientation and proximity sensors + CCD camera + thermographic sensors
S ₂₁	distance sensor + tilt sensor	\$100	ultrasonic sensor + Infrared sensor + dangerous gas sensor + noise sensor + ligh sensor
\$22	position sensor	\$101	lidar + IMU
\$23	rotation angles sensors + vacuum sensors + accelerometers + pressure sensor	\$102	ultrasonic + Infrared + laser
S24	light sensor + infrared proximity sensors	\$103	camera + laser scanners + inclinometer
\$25	infrared distance sensors + camera	\$104	gyro sensor + laser sensor + CCD camera
S26	shock sensor + infrared ray sensor + laser sensor, magnetic sensor	\$105	DSLR camera + rotating sensor
\$27	laser radar + GPS + RFID	\$106	camera + force + laser
\$28	alignment sensor + brake check sensor + obstacle detecting sensors + laser sensors + ultrasonic sensor + HMR sensor	\$107	radar + acoustic sensors + electrical resistivity sensors + impact-echo + ultrasonic + cameras
\$29	camera + laser + lidar	S ₁₀₈	camera + LED + light
\$30	GPS + generic pose sensor	\$109	GPS + camera
S31	tactile senses + force sensor	\$110	pressure sensor + Rotary encoder + potentiometer
S32	camera + GPS + dust meter	S ₁₁₁	camera + force + laser + pressure
\$33	force sensor + ultrasonic sensor	\$112	vision sensor + proximity sensor + periphera sensors
\$34	force sensor + sonar sensor	\$113	rotation angle + encoder sensor + laser accelerometer
\$35	vision sensor	\$114	ultrasonic sensors + encoders + IMU + yaw angle sensor + sonar sensors
\$36	optical sensors + touch sensor	S115	proximity sensor
\$37	ultrasonic sensor + 2D LIDAR	S116	IMU + force sensor
\$38	cameras + pressure force sensor	\$117	camera + encoder + proximity
\$39	camera + image + CCD + Kinect	\$118	camera + sonar sensor + temperature sensor + airflow sensors + laser
S40	position sensor + velocity sensor	S119	optical (IR) sensor
S41	position sensor + load sensor	\$120	pressure sensor + tensioner sensor + magneto strictive sensor
\$42	rotation sensor + force sensor	S ₁₂₁	meteor-sensors + proximity sensor + navigation sensor
S43	joint sensor	S ₁₂₂	power/torque sensor
S44	force sensor + pressure transducers	S123	force/ touch sensor
S45	force and position sensors + ground penetrating radar (GPR) + laser	\$124	photoelectric sensor
S46	force + pressure + laser	S ₁₂₅	ultra-sonic sensor + magnetic sensor + camera
S47	force sensors + laser + GPS + INS	S126	laser + camera + tempo sonics

\$48	work environment sensors + GPS + IMU + lidar	\$127	3D sensor
S49	infrared sensor	S128	force sensor + pressure sensor + provision sensor + vision sensors
\$50	position sensor + force sensor	\$129	optical + ultrasonic + laser
S51	bump sensor	\$130	camera + pressure sensor + displacement sensor
\$52	on-board camera + live video + inductive sensors	\$131	gyroscopes, force/torque sensor, video cameras
\$53	lidar + distance sensor + IMU + inductive sensor + contact sensors	S ₁₃₂	CCD cameras + acceleration sensors + position sensors + magnetic stroke sensors
S54	laser + cameras + Kinect	S133	stereo camera + acceleration sensors
\$55	load cell sensor	\$134	magnetic stroke sensors + pressure sensors + stereo camera
\$56	ultrasonic + position camera	\$135	force sensor + tracker sensor + stereo camera
\$57	environmental sensor	\$136	camera + position + pressure
\$58	F/T sensors force/torque + environmental sensor	\$137	position sensors + magnetic stroke sensors + pressure sensors
\$59	position and forces sensor	\$138	axis sensors
\$60	infrared sensor + force sensor + camera	\$139	stereo camera + acceleration sensors + a gyro sensor
S ₆₁	optical sensor + camera	\$140	pressure sensor + electronic compass + displacement transducers
S ₆₂	IMU	S ₁₄₁	angle sensor + ultrasonic sensors
\$63	proximity sensor + multiple sensors + camera	\$142	light sensors + humidity/temperature sensors + sonar sensors + ultrasonic range sensor + infrared distance measuring sensors + CMOS image sensor
S ₆₄	force + laser	\$143	GPS + IMU
\$65	camera + tactile	\$144	camera + angle + lidar + GPS
S66	GPS, position sensor, reference sensor	S145	attitude sensor + acceleration sensor + camera, displacement sensor
S67	GPS	\$146	Kinect + accelerometers + IMUs
S68	GPS + inclinometer	\$147	webcam
S69	GPS + laser	\$148	IMU + camera
\$70	laser + position	\$149	force-torque sensor + camera/vision
S71	force-torque + photoelectric sensor	\$150	RGB LED
S72	camera + proximity sensor + F/T sensor	S ₁₅₁	height sensor
\$73	tilt sensor + distance sensor + camera + laser scanner, gyroscope	S ₁₅₂	stroke sensor + temperature sensor + hydraulic sensor + potentiometer
S74	ultrasonic sensor + displacement transducers + ranging transducer + laser scanner	\$153	RFID + humidity sensor + temperature sensor + Kinect Sensor
\$75	laser distance + stereo infrared sensor	\$154	equivalent sensor
\$76	distance sensor	\$155	presence sensor + IR interrupt sensor + LVDT inductive sensors
S77	force sensor + pose sensor	S156	RGB camera + IMU
\$78	actuators and electronic sensors + stop sensor	\$157	Zigbee sensors + laser finder
S79	lidar + camera	\$158	depth sensor + colour sensors + camera

• hardware design labels

label	contents	label	contents
hd ₁	humanoid	hd42	mobile vehicle + aerial lift + manipulator +
hd ₂	arm, manipulator, mounted	hd44	vacuum suction device manipulator + vacuum suction + wheel mobility
hd₃	crawler	hd45	wearable
hd ₄	arm + slider pulley	hd ₄₆	wheel + magnetic gripper
hd ₅	multi-fingered, hand + gear + belt		mobile formwork
hd ₆	tank	hd48	reconfigurable + vacuum grippers+ arm +two robot
hd7	gantry robot, arm	hd49	robotized crane
hd_8	mobile robotic platform/robot		vacuum cups+ overhead gantry crane
hd ₉	AGV, track lifting arm	hd51	omnidirectional wheel, mobile platform, vacuum generator, robotic arm
hd ₁₀	traveling crane	hd ₅₂	mobile vehicle, carriage, truck, excavator, tank, trolley, dozer, Caterpillar, Forklift, machine
hd11	lifting rail + moved arm + carriage	hd53	wireless gripper, winch
hd ₁₂	fixed arm (depicted, mounted, hang on, manipulator, attach)	hd54	vacuum gripper + arm
hd ₁₃	mobile platform + arm, manipulator	hd55	vertically mobile arm
hd ₁₄	changeable cell	hd56	rail moving arm
hd ₁₅	wheel mobile lifting single arm	hd57	wire, cable climb
hd ₁₆	climbing platform + pediculate + gripper	hd58	UAV
hd ₁₇	lift fixed manipulator	hd59	scissor lift + aerial bucket + manipulator arm
hd ₁₈	the legged mobile platform with rods climbs	hd_{60}	truss-type
hd19	climbing platforms + vacuum grippers + suction	hd ₆₁	excavator arm + double front
hd ₂₀	climbing two platforms + light skeleton + vacuum grippers	hd ₆₂	caterpillar + 6-DOF manipulator + vacuum pad
hd ₂₁	mobile arm	hd ₆₃	scissor-jack manipulator
hd22	mobility platform + magnetic gripper	hd ₆₄	ground-based, aerial robotic platform
hd ₂₃	mobile + light + manipulator + rail	hd ₆₅	mobile square
hd ₂₄	climbing system	hd ₆₆	mobile tracked locomotion
hd25	parallel robot	hd ₆₇	frame system
hd ₂₆	rail, vertical-moving robot	hd ₆₈	mobile platform Husky
hd ₂₇	AGV, unmanned ground vehicle	hd ₆₉	platform clamp
hd ₂₈	Hexapod-Shaped	hd70	mobility feet, leg, limbed
hd ₂₉	a mobile platform, a manipulator mounted on a lifting column	hd71	wheel + platform + caterpillar
hd30	industrial robot, ABB arm, arm, KUKA arm, Mitsubishi Robot RV-2AJ, manipulator, UR5	hd ₇₂	Hammering
hd31	UGV + UAV	hd73	magnetic wheel
hd32	wheel mobile robot	hd ₇₄	worm-like, snake-like
hd33	bucket + arm	hd ₇₅	clamping manipulator
hd34	vertical mobile + cleaning head + pressure pump + suction device + filter + tank	hd76	scissor lifter + omnidirectional wheels
hd35	magnetic clamp and mobile platform	hd77	bolting robot
hd36	mobile arm, manipulator + wheels	hd ₇₈	collaborative, multi, team, multiple

hd ₃₇	reconfigurable + platform	hd79	omnidirectional wheel
hd38	reconfigurable + vertical + climbing	hd_{80}	3d printer, lifting
hd39	reconfigurable + locomotive wheel	hd ₈₁	motion base, manipulator
	caterpillar wheel + commercial impeller, + vacuum suction	hd ₈₂	artificial Nbber/ Rubber muscle (PARM)
hd41	parallel manipulator, frame	hd ₈₃	furniture system, terminal wall system

• benchmarking technique labels

label	contents
bm_1	environmental + life cycle Assessment (LCA)
bm_2	technical + economic + efficiency
bm3	efficiency
bm_4	motion + force + transmissibility
bm5	safety + posture load + working environment + risk exposure time+ safety
bm_6	cost + quality
bm_7	productivity + economic + sensitivity + safety + quality
bm_8	cost + productivity + sensitivity
bm9	material management
bm ₁₀	position + internal + error + force
bm ₁₁	grasping + force + perception
bm ₁₂	sustainability +performance + environment
bm ₁₃	error + cost + power consumption + controllability + complexity continuous time
bm ₁₄	cost + productivity + efficiency
bm ₁₅	mental workload