Karlsruhe Institute of Technology

IR@MI Workshop, 25th October 2012

Human-Robot-Interaction in manufacturing - a historical retrospective

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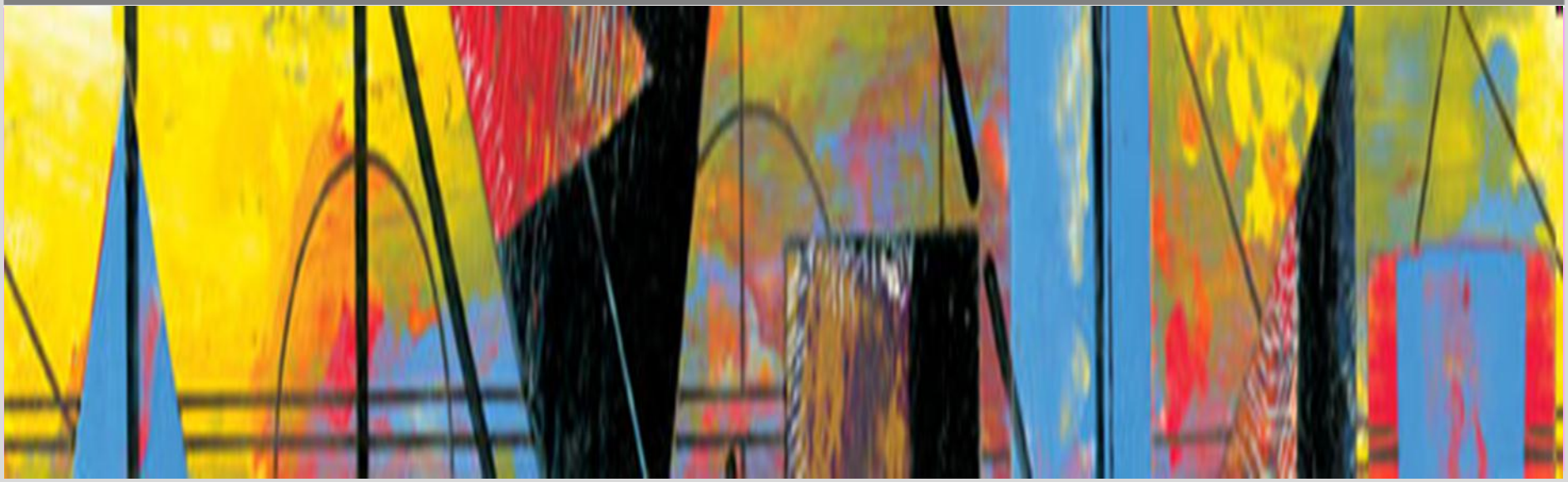


What is/was going on in the research towards Human-Robot-Interface in manufacturing?

Research approach

- Database research (number articles per year)

  I) sequential search with either one string or multible strings combined by boolean operators

AND	Results must contain all your terms.
OR	Results must contain either this term or the previous term.
AND NOT	Results must not contain this term.

  II) sequential search with one string

- Derivation of debate trends based on database research results

Database research I

String	Number articles	code
Robotic	78,866	A
Human AND robot AND interface	6,102	B(A)
Human AND robot AND interaction	7,542	C(A)
industry	2,568	D(B(A))
	2,596	G(C(A))
service	2,367	E(B(A))
Medical	2,033	F(B(A))
Manufacturing (topic)	108	H(C(A))

- Database:
  - science direct (http://www.sciencedirect.com/)
- Defined search string
- Search in:
  - all fields,
  - all sources
  - all years
- Search date: 11.10.2012

C(A), topic

- artificial intelligence (227)
- robot (211)
- neural network (146)
- autonomous system (140)
- mobile robot (109)
- **manufacturing system (108)**
- inter face (105)
- expert system (65)
- control system (56)
- soft ware (54)
- robotic (51)
- virtual reality (51)
- fax (49)
- petri net (43)
- theta (43)
- humanoid robot (42)
- computer science (40)
- robotic system (39)
- delta (38)
- kalman filter (38)

H(C(A))

system volume (19)

flexible manufacturing (15)

integrated manufacturing (4)

intelligent manufacturing (4)

manufacturing (4)

automated manufacturing (3)

advanced manufacturing (2)

assembly system (2)

cad (2)

cellular manufacturing (2)

cim (2)

computer integrated (2)

error recovery (2)

holonic manufacturing (2)

intelligent system (2)

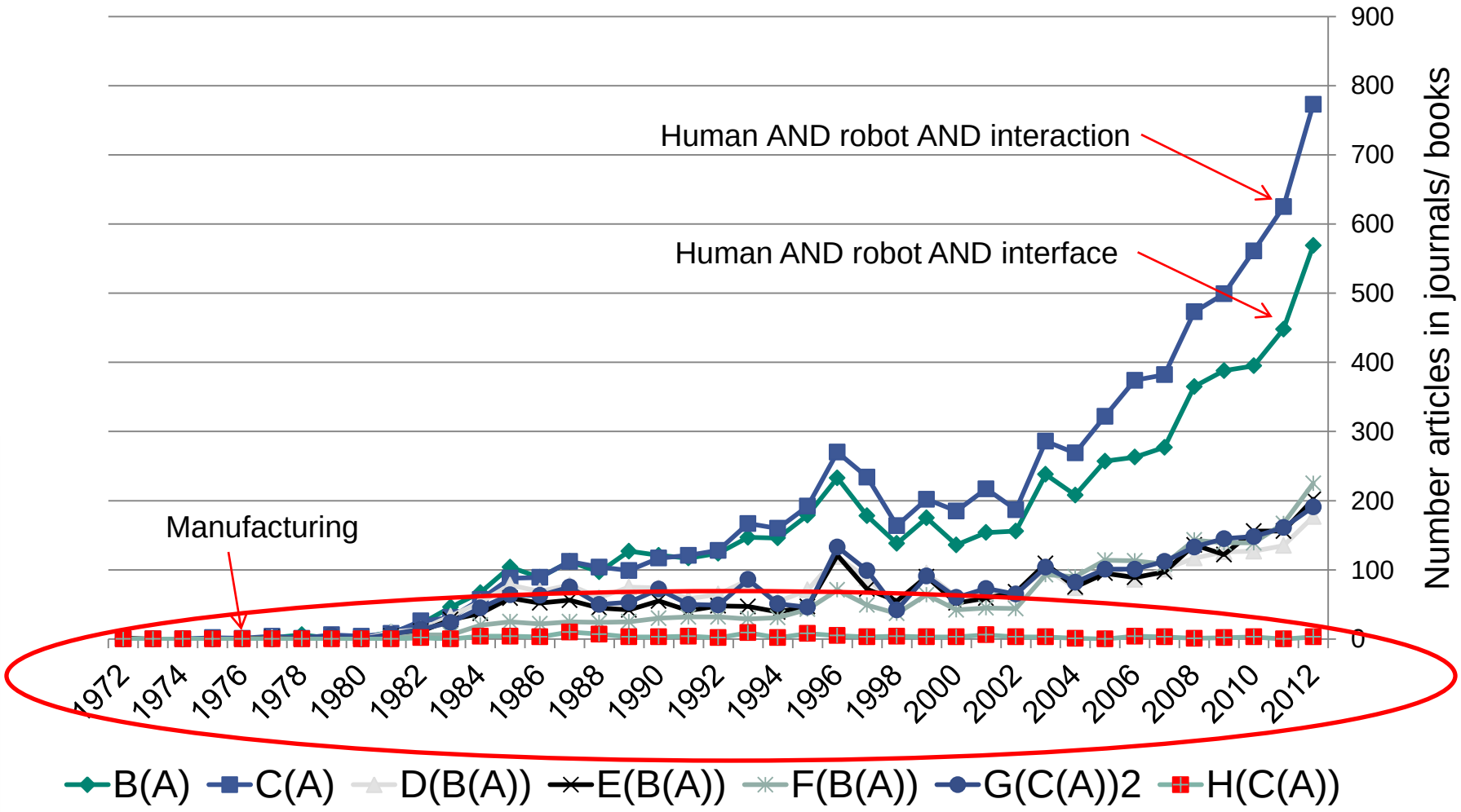
manufacturing technology (2)

neural network (2)

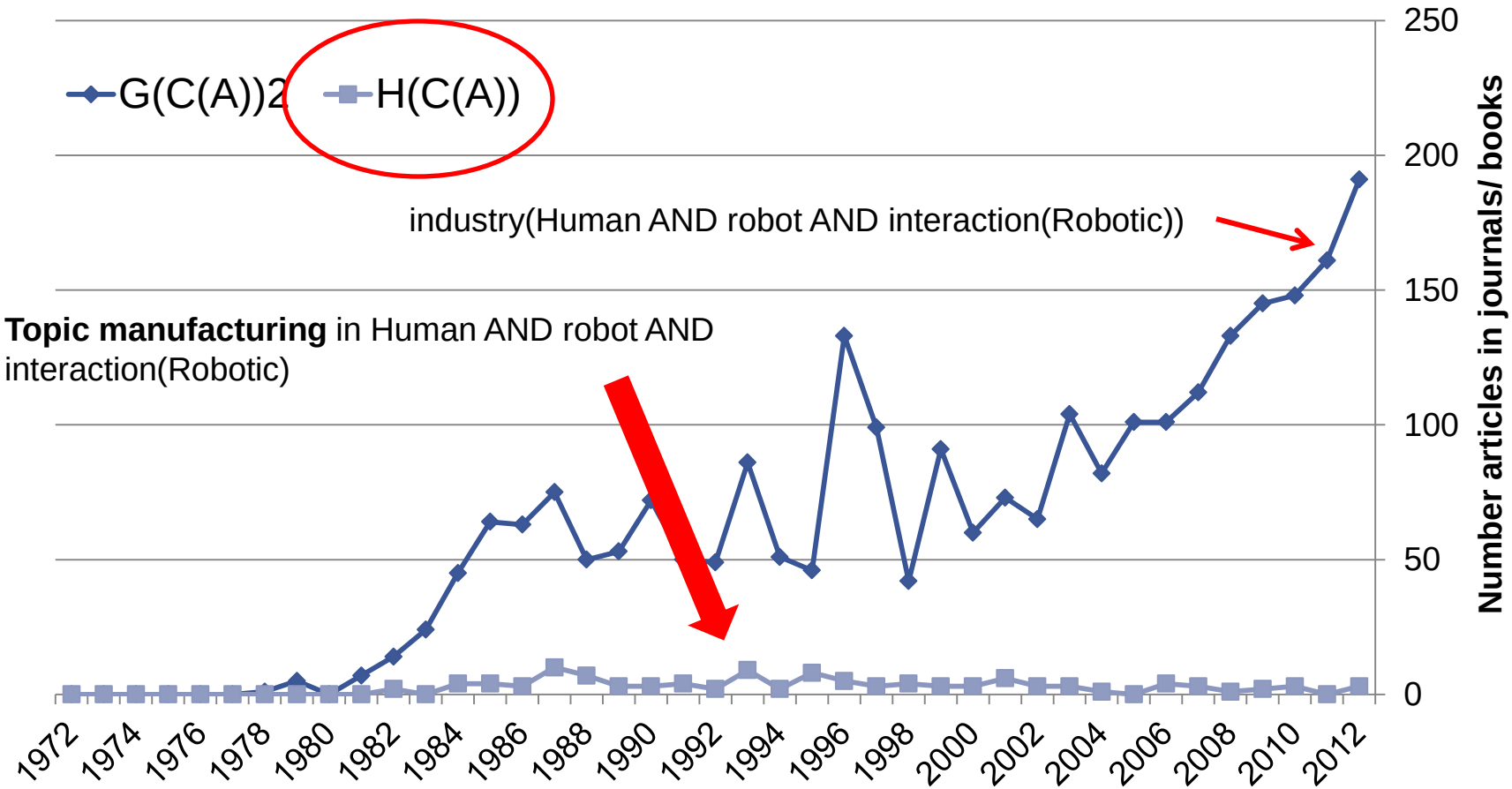
pattern recognition (2)

resource model (2)

Database research results



Human - robot – interaction in manufacturing



Journals

H(C(A))

	2012	2001	1993	1987
Engineering Applications of Artificial Intellig...	1			
Journal of Manufacturing Systems	**1**	**2**	**8**	**5**
Procedia CIRP /CIRP Annals - Manufacturing Technology	1	2		1
Handbook of Production Management Methods		1		
Robotics and Computer-Integrated Manufacturing		1		1
Computer Integrated Manufacturing Systems			1	
Computers & Industrial Engineering				1

Paper topics

2012	2001	1993	1987
S. Makris, G. Michalos, A. Eytan, G. Chryssolouris, ***Cooperating Robots for Reconfigurable Assembly Operations: Review and Challenges,***	K. Ueda, A. Markus, L. Monostori, H.J.J. Kals, T. Arai, ***Emergent Synthesis Methodologies for Manufacturing,***	D. Veeramani, B. Bhargava, M.M. Barash, ***Information system architecture for heterarchial control of large FMSs,***	Ahmad K. Elshennawy, Chin H. Lee, ***Human-computer interaction in manufacturing,***
Paulo Leitão, José Barbosa, Damien Trentesaux, ***Bio-inspired multi-agent systems for reconfigurable manufacturing systems***,	Cem M. Baydar, Kazuhiro Saitou, ***Automated generation of robust error recovery logic in assembly systems using genetic programming***,	F. Puls, M. Barash, ***An adaptive control algorithm for robotic deburring***	Hoda A. El Maraghy, ***Computer integrated manufacturing education and research,***
J. Padayachee, G. Bright, ***Modular machine tools: Design and barriers to industrial implementation,***	Jay Steele, Young-Jun Son, Richard A. Wysk, ***Resource modeling for the integration of the manufacturing enterprise,***	Alan C. Lin, Tien-Chien Chang, ***3D MAPS: Three-dimensional mechanical assembly planning system***,	Jack R. Meredith, ***Managing factory automation projects,***
	E. Westkämper, R. von Briel, ***Continuous Improvement and Participative Factory Planning by Computer Systems,***	Fred Hansen, Elias Pavlakos, Eric Hoffman, Takeo Kanade, Raj Reddy, Paul Wright, ***PARES: A prototyping and reverse engineering system for mechanical parts-on-demand on the national network,***	Michel A. Melkanoff, ***Education for intelligent manufacturing systems***,
	Lihui Wang, ***Integrated design-to-control approach for holonic manufacturing systems,***	N. Duffie, R. Chitturi, J. Mou, ***Fault-tolerant heterarchical control of heterogeneous manufacturing system entities***	Jack R. Meredith, ***Implementing the automated factory,***
		P. Chao, P. Ferreira, C. Liu, ***Applications of GMDH-type modeling in manufacturing***	John L. Casti, ***Manufacturing as a system-determined science***,
		H. Wu, R. Venugopal, M. Barash ***Design of a cellular manufacturing system: A syntactic pattern recognition approach***	Edward L. Fisher, Shimon Y. Nof, ***Knowledge-based economic analysis of manufacturing systems,***
		A. Jones, C. McLean ***A proposed hierarchical control model for automated manufacturing systems***	G.J. Miltenburg, ***Economic evaluation and analysis of flexible manufacturing systems,***
			John R. Crookal, ***Education for CIM***,

H(C(A))

Database research II

String	Number articles	code
robot	66,341	I
human	30,478	J(I)
work	24,433	K(J(I))
interaction	13,153	L(K(J(I)))
manufacturing	3,560	M(L(K(J(I))))

- Database:
  - science direct (http://www.sciencedirect.com/)
- Defined search string
- Search in:
  - all fields,
  - all sources
  - all years
- Search date: 16.10.2012

Topics

I - robot

neural network (1,068)
artificial intelligence (776)
robot (685)
radical prostatectomy (656)
mobile robot (628)
manufacturing system (611)
delta (583)
usa (531)
autonomous system (410)
control system (408)
theta (404)
soft ware (400)
expert system (371)
omega (327)
computer science (325)
prostate cancer (307)
pattern recognition (289)
inter face (287)
fax (260)
kalman filter (252)

J - human

neural network (536)
artificial intelligence (528)
robot (403)
manufacturing system (287)
mobile robot (277)
autonomous system (265)
expert system (255)
usa (253)
soft ware (236)
inter face (225)
control system (152)
delta (148)
pattern recognition (127)
fuzzy logic (121)
fax (116)
computer vision (115)
theta (114)
robotic (112)
computer science (107)
virtual reality (106)

K - work

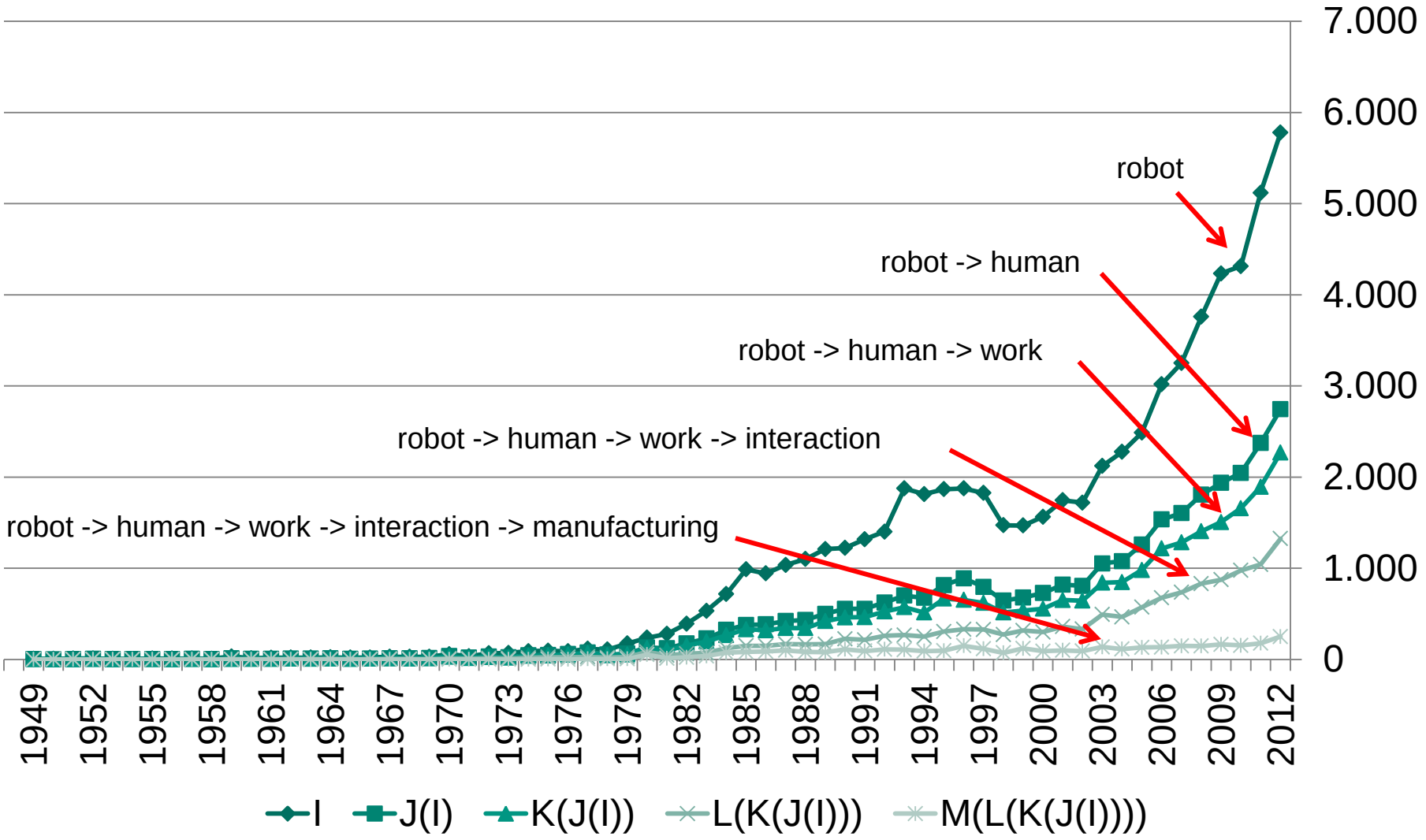
artificial intelligence (455)
neural network (453)
robot (362)
manufacturing system (265)
mobile robot (240)
autonomous system (225)
expert system (216)
soft ware (205)
inter face (200)
delta (125)
control system (119)
fuzzy logic (107)
computer vision (99)
pattern recognition (97)
robotic (94)
theta (94)
kalman filter (92)
petri net (90)
genetic algorithm (82)
human factor (82)

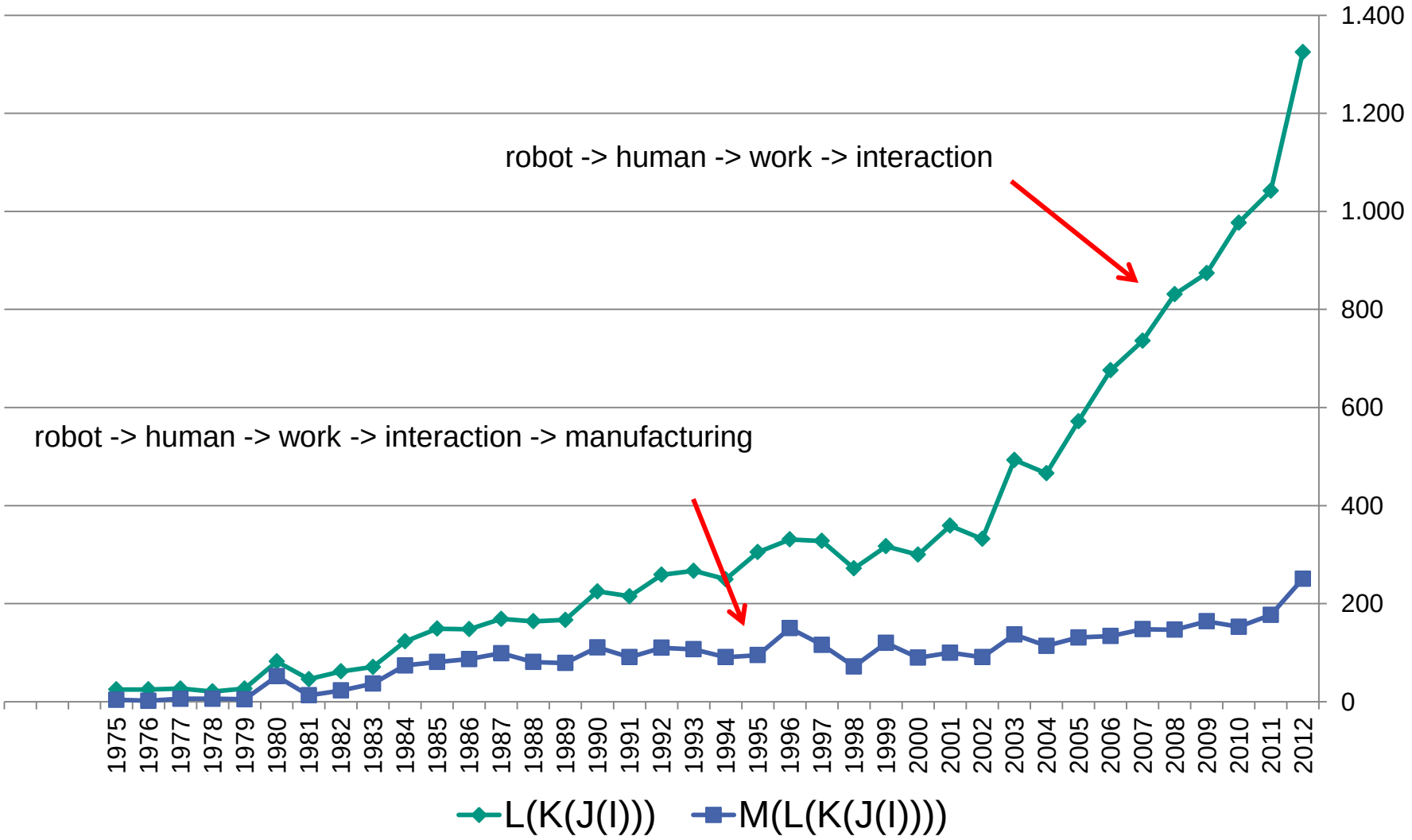
L - interaction

artificial intelligence (310)
robot (209)
neural network (196)
inter face (166)
manufacturing system (151)
soft ware (138)
autonomous system (134)
expert system (119)
mobile robot (97)
control system (72)
virtual reality (71)
petri net (61)
delta (58)
anti body (54)
agent (53)
internet (51)
pergamon press (50)
robotic (48)
reinforcement learning (47)
computer science (46)

M - manufacturing

manufacturing system (151)
artificial intelligence (82)
expert system (82)
robot (61)
neural network (58)
pergamon press (49)
petri net (49)
soft ware (47)
control system (45)
autonomous system (41)
inter face (40)
cad (30)
flexible manufacturing (30)
virtual reality (29)
industrial robot (27)
human factor (26)
robotic (26)
mobile robot (24)
internet (23)
cim (22)


7.000
6.000
5.000
4.000
3.000
2.000
1.000
0
robot
robot -> human
robot -> human -> work
robot -> human -> work -> interaction
robot -> human -> work -> interaction -> manufacturing
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
I
J(I)
K(J(I))
L(K(J(I)))
M(L(K(J(I))))


robot -> human -> work -> interaction
robot -> human -> work -> interaction -> manufacturing
1.400
1.200
1.000
800
600
400
200
0
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
L(K(J(I)))
M(L(K(J(I))))

Debate trends

- What are the main topics in HRI in manufacturing? Today, in the past?
- What are the involved communities? Today, in the past?
- Have topics been shifted to other communities?
- What are the reasons for the stagnating trend of publications in manufacturing? Database research, political- or academic reasons?
- What are the reasons for the publication peaks?