



**IEEE Robotics and Automation's  
Technical Committee on Micro/Nano  
Robotics and Automation**

***Triennial review report***

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## 1. Introduction – Scope of the TC

The Technical Committee on Micro/Nano Robotics and Automation corresponds to specific challenges and paradigms in the RAS area, notably due to the dimensional scales addressed. Predominance of physical phenomena (static and dynamic) at the micro and nano scales is most often markedly different from their macroscopic counterpart, and this has strong implications on robotic strategies, algorithms, software and hardware for manipulation, locomotion and control.

From the applications point of view, micro and nanorobotics already and potentially have many applications, in biology, medicine, micro/nanotechnologies and sciences, industry (e.g. microassembly) and we are convinced that it will bring very efficient tools in many cases.

At last we consider the name of this TC totally topical as it corresponds to still an emerging scientific and technological area.

**In the past 3 years we tried to be very active and to use this TC as an efficient way to promote, stimulate and interact worldwide in this very promising field.**

## 2. TC Activities in the past 3 years

### Membership

Prof. Aristides Requicha (University of Southern California, USA, **Region 6**) and Prof. Fumihito Arai (Tohoku University, Japan, **Region 10**) were Co-Chairmen these past three years. Prof. Requicha was Corresponding Chairman in 2006 and Prof. Arai in 2007. Prof. Nicolas Chaillet (University of Franche-Comté, France, **Region 8**) joined them in November 2006 as a Co-Chairman and became Corresponding Chairman in 2008.

***Then, the Co-Chairmen cover three primary regions and a regular alternation occurs for the corresponding responsibility.***

Table 1 gives the attendance of TC Co-Chairs at TAB meetings and GOLD lunches.

	TAB meetings	GOLD lunches
ICRA 2006	A. Requicha	A. Requicha
ICRA 2007	N. Chaillet, A. Requicha	A. Requicha, N. Chaillet
IROS 2007	N. Chaillet, A. Requicha	A. Requicha
ICRA 2008	F. Arai	F. Arai
IROS 2008	F. Arai	F. Arai
ICRA 2009 (foreseen)	N. Chaillet	N. Chaillet

**Table 1. Attendance at TAB meetings and GOLD lunches.**

Fig.1 gives the number of TC members per year. It can be seen that the number increased continuously. The policy in this TC is to welcome new and notably young members (see the “How to participate in the TC activities“ Section in the TC website <http://rastc-mnra.in2p3.fr> ) but we also think that TC membership has to be seen as an acknowledgement to be a leader in the field. Then each new membership has to be approved by TC members. Moreover a reasonable number of TC members can efficiently share information and react quickly.

In this TC the communication with the members and from the members is very regular. Mainly, information concerning Workshops, Conferences, Special Issues updates and various events (e.g. RoboCup Nanogram) is exchanged. For instance in 2008, more than 1 email per month was sent by the Chairmen to all TC members.

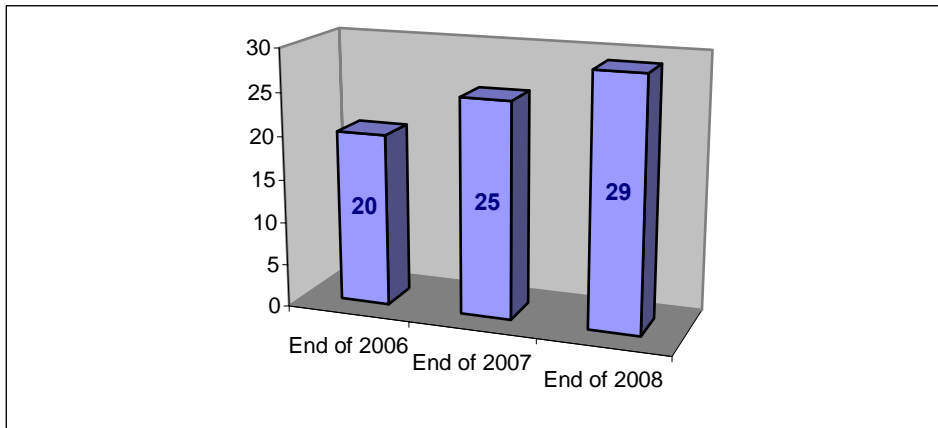


Fig. 1. Histogram of TC members per year.

### Conferences and publications

The Micro/Nano Robotics and Automation section of the RAS website (see <http://tab.ieee-ras.org/committeeinfo.php?tcid=13>) gives the amount of activities since 2006 (as exhaustive as possible list). It can be seen that the TC is very active, members organize each year Workshops/Tutorials, notably at ICRA and IROS (see Table 1, extracted from the website data). Several Workshops and invited sessions (not listed in Table 1 but given in the website) were also organized in other IEEE Conferences (e.g. BIOROB, ISAM, ICMA).

	Workshops (Conf., number)	Tutorials
<b>2006</b>	ICRA, 1	
<b>2007</b>	IROS, 2	IROS, 1
<b>2008</b>	IROS, 1	
<b>2009 (accepted)</b>	ICRA, 2	

Table 2. Workshops and Tutorials in major RAS conferences.

Moreover, the scientific area covered by the TC is clearly present in RAS conferences as it can be seen from Fig.2.

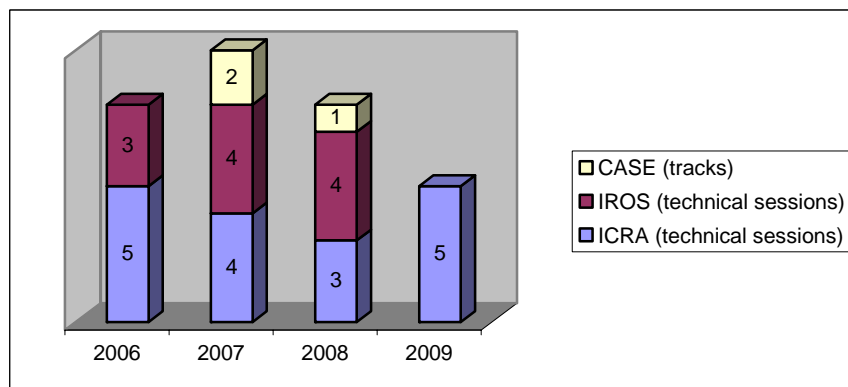


Fig. 2. Number of sessions in major RAS conferences.

3 special issues of journals, 2 books (+ 1 to be published in 2009, directly born from a Workshop organized at IROS 2007) and 4 tutorial/survey papers in RAM were published from 2006 to 2009 (see appendix for detailed information). 4 papers received an award from IEEE RAS Conference and Journal (see appendix). At least 4 International Symposiums were chaired and organized by TC members (see appendix).

Many important papers were published over past 3 years in the TC area and it is very difficult to choose. In addition to the papers which received awards and in accordance with the previous and current *Recent Innovations Summary slide*, the appendix gives some selected publications which represents recent trends in the TC area.

## Outreach activities

As it can be seen from the website <http://tab.ieee-ras.org/committeinfo.php?tcid=13> activities outside the RAS were also organized by TC members. We can for instance highlight here the RoboCup Nanogram demonstration organized by NIST (see <http://www.robocup2009.org/267-0-demonstrations.html> ).

## Report and website

The **Recent Innovations Summary** slide is updated each year before ICRA. The Micro/Nano Robotics and Automation section of the RAS website (<http://tab.ieee-ras.org/committeinfo.php?tcid=13>) is regularly updated as soon as one TC member gives new material (much more than twice a year).

A totally new Micro/Nano Robotics and Automation website was created in November 2008: see <http://rastc-mnra.in2p3.fr>. It gives additional information to the RAS website: list of members, how to participate in the TC activities, some illustrations for the TC.

## Top three technical innovations

1. Emergence of Nanosensors and Nanoactuators (which open the way to future nanorobots) and automatic nanomanipulation for small (~10 nm) nanoparticles with AFMs.
2. System Integration of MEMS/NEMS and Robotic Technology (e.g. Assembly, medical, microfluidic systems, etc.).
3. Bio-inspired Micro/Milli Robots.

## 3. TC Activities in the next 3 years

Our goal for the next 3 years is of course to get on with the promotion of scientific activities related to the TC area through the regular organization of events such as workshops and tutorials, as well as special issues in major scientific journals.

Concerning 2009, as it was already mentioned, 2 Workshops will be held at ICRA and one collective book will be published (Ed. JOHN WILEY & SONS).

A spotlight column describing our TC was accepted for the March 2010 issue of RA magazine. It will be the occasion to communicate new results and the excitement of our TC research area. We will increase the dissemination of new results using various kinds of media.

Basically the scientific issues addressed by the TC are very open and the scientific community is very dynamic but still small. Then one goal of the TC is to increase the interest of young people for the TC area. TC will stimulate the tutorial activities. TC co-chairs will request from TC members to organized more tutorials, notably in RAS conferences. Moreover, the participation to the RoboCup Nanogram will be encouraged as it is a good way for emulation and dissemination.

Concerning the current TC members, IEEE Regions are covered but the geographic representation is not really well balanced: 13 of them are in Europe, 12 in America (Regions 1-7) and 4 in Asia. We will then recruit new highly skilled and motivated members notably from the Asia side (in particular China, Korea, Singapore), who is active in the TC area. We will also request members from emerging countries.

Concerning the co-chairs, the co-chair from Region 6, who outstandingly serves the TC and the scientific community, will change in the next 3 years. One TC member from the same region will serve (among the very well-known researchers who are already TC members).

In order to stimulate relationship between research and industry in the TC area, we will also recruit members from industry. It is now more possible as technology corresponding to the TC area is now more and more present in industry (e.g. microassembly).

Doing this and maintaining our strong motivation for communication, workshops, special issues, etc., we will then increase our capacity to manage a substantial mass of activities and to generate new initiatives, in order to establish our research field worldwide and to serve IEEE RAS membership.

#### 4. Conclusion

Many activities were achieved by the TC members to stimulate the community during the last three years and we have to thank all of them for their enthusiasm. As Co-Chairmen, we tried to drive the TC in a dynamic and interactive way.

**Most of the scientific and technological issues addressed by this TC are still in their infancy (notably at the nanoscale). We think that many breakthroughs and a growing number of applications will take place in the future, and we are convinced that the Micro/Nanorobotics and Automation TC remains necessary to activate, highlight and increase the still small corresponding community at the IEEE RAS level and is a very good tool to stimulate the keen interest for the corresponding research. We then deeply hope that it will be supported by IEEE RAS.**

## Appendix

### → Special issues

**IEEE T-ASE** Special issue on Nanoscale Automation and Assembly, Vol.3, No.3, 2006  
Guest Editors: Wen J. LI, Ning XI

**Journal of Micromechatronics/Micro/Nano Handling** Special issue on Micro/Nano Handling, Vol.3, No.3-4, 2006  
Guest Editors: Quan Zhou, Anna Eisinger and Arianna Menciassi.

**International Journal of Robotics Research** Special issue on Nanorobotics, Vol.28, No.4, 2009  
Guest Editors: Antoine Ferreira, Constantinos Mavroidis

### → Books

**Capillary Forces in Microassembly: Modeling, Simulation, Experiments and Case Study** Pierre Lambert, Ed.  
Springer, ISBN: 978-0-387-71088-4, 2007

**Automated Nanohandling by Microrobots** Sergej Fatikow, Ed. Springer, ISBN: 978-1-84628-977-4, 2008

**Robotic Microassembly** Michaël Gauthier and Stéphane Régnier, Ed. JOHN WILEY & SONS, to be published in 2009

### → Survey papers, tutorials

**Microscale and nanoscale robotics systems (Grand Challenges of Robotics)** *Survey* Sitti M., IEEE Robotics & Automation Magazine, Vol. 14, No. 1, Page(s):53 – 60, March 2007.

**Robotics in the Small, Part I: Microrobotics** *Tutorial* Abbott, J.J., Nagy, Z., Beyeler, F., Nelson, B.J., IEEE Robotics & Automation Magazine, Vol. 14, No. 2, Page(s):92 – 103, June 2007.

**Robotics in the Small, Part II: Nanorobotics** *Tutorial* Dong L.X. and Nelson B.J., IEEE Robotics & Automation Magazine, Vol. 14, No. 3, Page(s):111-121, September 2007.

**Nanomanipulation with the Atomic Force Microscope** *Tutorial/Survey* Requicha A. A. G., in R. Waser, Ed., *Nanotechnology, Volume 3: Information Technology*. Weinheim, Germany: Wiley-VCH 2008, pp. 239-273.

### → Awards

**Nanorobotic Spot Welding by Attogram Precision from Copper-Filled Carbon Nanotubes** Lixin Dong, Xinyong Tao, Li Zhang, Xiaobin Zhang, and Bradley J. Nelson, Proc. ICRA 2007, pp. 1425-1430, Finalist Best Automation Paper Award.

**Towards Nanotube Linear Servomotors** Lixin Dong, Bradley J. Nelson, Toshio Fukuda and Fumihito Arai, IEEE T-ASE, Vol. 3, No. 3, pp.228-235, July 2006, Googol Best New Application Paper Award 2007.

**Fabrication of Functional Gel-Microbead for Local Environment Measurement in Microchip** Hisataka Maruyama, Fumihito Arai, Toshio Fukuda, Proc. ICRA 2008, pp. 305-310, Best Automation Paper.

**Pioneer in Robotics an Automation Award** A. A. G. Requicha, RAS 2008.

### → Symposiums

**(Co-Sponsored by IEEE Robotics and Automation Society)**

**2006 International Symposium on Micro-NanoMechatronics and Human Sciences**  
General Co-Chair Toshio Fukuda, Program Co-Chair Fumihito Arai, Nov. 5 - Nov. 8, 2006.

**2007 International Symposium on Micro-NanoMechatronics and Human Sciences**  
General Co-Chair Toshio Fukuda, Program Co-Chair Fumihito Arai, Nov. 11 - Nov. 14, 2007.

**2008 International Symposium on Micro-NanoMechatronics and Human Sciences**  
General Co-Chair Toshio Fukuda, Program Co-Chair Fumihito Arai, Nov. 6 - Nov. 9, 2009.

**(Label from the IEEE France Section)**

**2006 International Workshop on Microfactories**  
General Co-Chair Philippe Lutz, Hannes Bleuler, Oct. 25-27, 2006, Besançon, France

→ **Some selected publications**

**CAD/CAM for nanoscale self-assembly** A. A. G. Requicha and D. J. Arbuckle, IEEE Computer Graphics and Applications, Vol. 26, No. 2, pp. 88-91, March/April 2006.

**Method of propulsion of a ferromagnetic core in the cardiovascular system through magnetic gradients generated by an MRI system** J.-B. Mathieu, G. Beaudoin, and S. Martel, IEEE Transactions on Biomedical Engineering, vol. 53, no. 2, pp. 292-299, Feb. 2006

**In-situ Nanorobotic Soldering of Three-dimensional Helical Nanobelts using Gold Nanoink** G. Hwang, C. Dockendorf, D. J. Bell, L. Dong, H. Hashimoto, D. Poulidakos, and B. J. Nelson, Proc. of the 7th IEEE International Conference on Nanotechnology, August 2 - 5, 2007, Hong Kong

**Principle of a submerged freeze gripper for micro-assembly** B. Lopez-Walle , M. Gauthier, N. Chaillet , IEEE Transactions on Robotics, 24 (4), pp. 897-902, 2008

**Enhanced Accuracy of Force Application for AFM Nanomanipulation Using Nonlinear Calibration of Optical Levers** H. Xie, J. Vitard, D. S. Haliyo, and S. Régnier, IEEE Sensors Journal, 8 (24), pp. 1478-1485, Aug. 2008.

**Effective and Efficient Locomotion for Millimeter-Sized Microrobots** S. Bergbreiter, Proc. Of IEEE/RSJ IROS 2008, pp. 4030-4035, Sept. 2008, Nice, France.

**Wireless resonant magnetic microactuator for untethered mobile microrobots** K. Vollmers, D. R. Frutiger, B. E. Kratochvil, B. J. Nelson, Applied Physics Letters, Vol. 92, No. 14, 2008.

**Nano Robotic Manipulation inside Electron Microscopes** T. Fukuda, M. Nakajima, and P. Liu, SICE Journal of Control, Measurement and System Integration, SICE, Vol. 1, No. 1, pp. 40-50, (2008)