



# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research



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| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                          |                                                     | Form Approved<br>OMB No. 0704-0188                          |                                 |
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| 1. REPORT DATE<br><b>04 MAY 2004</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    | 2. REPORT TYPE<br><b>Briefing Charts</b> |                                                     | 3. DATES COVERED<br><b>08-01-2004 to 14-04-2004</b>         |                                 |
| 4. TITLE AND SUBTITLE<br><b>Automated Text Mining Comparison of Japanese and USA Multi-Robot Research</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                          |                                                     | 5a. CONTRACT NUMBER                                         |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          |                                                     | 5b. GRANT NUMBER                                            |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          |                                                     | 5c. PROGRAM ELEMENT NUMBER                                  |                                 |
| 6. AUTHOR(S)<br><b>Robert Watts; Alan Porter; Brian Minsk</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                    |                                          |                                                     | 5d. PROJECT NUMBER                                          |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          |                                                     | 5e. TASK NUMBER                                             |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          |                                                     | 5f. WORK UNIT NUMBER                                        |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Search Technology, Inc,6025 The Corners Parkway ,Suite 202,Norcross,GA,30092</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                          |                                                     | 8. PERFORMING ORGANIZATION REPORT NUMBER<br><b>; #14060</b> |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br><b>U.S. Army TARDEC, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    |                                          |                                                     | 10. SPONSOR/MONITOR'S ACRONYM(S)<br><b>TARDEC</b>           |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          |                                                     | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)<br><b>#14060</b>     |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                          |                                                     |                                                             |                                 |
| 13. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                          |                                                     |                                                             |                                 |
| 14. ABSTRACT<br><b>Briefing Charts</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                    |                                          |                                                     |                                                             |                                 |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                          |                                                     |                                                             |                                 |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                          | 17. LIMITATION OF ABSTRACT<br><b>Public Release</b> | 18. NUMBER OF PAGES<br><b>14</b>                            | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b>      |                                                     |                                                             |                                 |



# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

**SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY**

## Briefing Outline:

1. What's Tech OASIS
2. Discuss the Data being Analyzed
  - Field Delimited
  - Multi-Robot Research
3. Processes for Segmenting Data
  - Deductive – Expert Opinion
  - Inductive – PCA based analysis
4. Expectancy Measure
5. Expectancy Measure applied to Segmented data
6. Observations & Interpretations
7. Conclusions & Recommendations



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SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Tech OASIS - A Software System for:

- Knowledge Discovery in Large Text Databases
- Profiling Thousands of Research Abstracts

### Technology Scanning

Identifying new technologies and new developments in existing technologies

### Technology Profiling

Identify key people and organizations

### Technology Mapping and Decomposition

Identify dependencies and relationships

### Technology Trending

Establish how a technology has emerged

### Technology Forecasting

Project how a technology could evolve







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FN- DIALOG(R)File 8:Ei Compendex(R)|

CZ- (c) 2004 Elsevier Eng. Info. Inc. All rts. reserv. |

AN- <DIALOG> 06259509|

TI- <MAIN> Guest editorial advances in multirobot systems|

AU- Arai, Tamio^Pagello, Enrico^Parker, Lynne E. |

CS- University of Tokyo Department of Precision Engineering, Tokyo, Japan|

SO- <S2> IEEE Transactions on Robotics and Automation v 18 n 5 October 2002. p 655-661|

DT- JA^(Journal Article)|

AB- <Abstract> As research progresses in distributed robotic systems, more and more aspects of multirobot systems are being explored. This Special Issue on Advances in Multirobot Systems provides a broad sampling of the research that is currently ongoing in the field of distributed mobile robot systems. To help categorize this research, we have **identified seven primary research topics within multirobot systems:** biological inspirations, communication, architectures, localization/mapping/exploration, object transport and manipulation, motion coordination, and reconfigurable robots. This editorial examines these research areas and discusses the Special Issue papers in this context. We conclude by identifying several additional open research issues in distributed mobile robotic systems. 71 Refs. |

DE- <Descriptors> \*Multipurpose robots^Mobile robots^Robotics^Computer simulation|

ID- <Identifiers> Multirobot systems|

CC- <C2> 731.5 \_(Robotics)^731.6 \_(Robot Applications)^723.5 \_(Computer Applications)|





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**SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY**

## 7+2 IEEE Imposed Categories

IEEE Imposed Categories  
“Guest Editorial,  
Advances in Multirobot  
Systems”

- 354 EI Compendex & INSPEC abstracts
- Expert Perceived Research Categories
- 324 abstracts grouped

- Deductive Categories
- Expert Field Awareness (e.g., Reconfigurable)

| #   | # Records | IEEE MultiRobot Groups           | IEEE MultiRobot Groups          |                     |               |                                  |            |                                 |                |                 |            |                |
|-----|-----------|----------------------------------|---------------------------------|---------------------|---------------|----------------------------------|------------|---------------------------------|----------------|-----------------|------------|----------------|
|     |           |                                  | # Records                       | 142                 | 139           | 114                              | 61         | 61                              | 44             | 42              | 41         | 30             |
| #   | # Records | IEEE MultiRobot Groups           | Architecture Allocation Control | Motion Coordination | Communication | Localization Mapping Exploration | Biological | Transport Manipulation Grasping | Robot Learning | Human Interface | IEEE OTHER | Reconfigurable |
| 142 |           | Architecture Allocation Control  | 142                             | 55                  | 45            | 27                               | 27         | 24                              | 14             | 9               |            | 4              |
| 139 |           | Motion Coordination              | 55                              | 139                 | 38            | 20                               | 22         | 17                              | 16             | 19              |            | 4              |
| 114 |           | Communication                    | 45                              | 38                  | 114           | 31                               | 25         | 10                              | 7              | 12              |            | 2              |
| 61  |           | Localization Mapping Exploration | 27                              | 20                  | 31            | 61                               | 9          | 8                               | 5              | 8               |            | 4              |
| 61  |           | Biological                       | 27                              | 22                  | 25            | 9                                | 61         | 6                               | 5              | 5               |            | 2              |
| 44  |           | Transport Manipulation Grasping  | 24                              | 17                  | 10            | 8                                | 6          | 44                              | 7              | 6               |            | 4              |
| 42  |           | Robot Learning                   | 14                              | 16                  | 7             | 5                                | 5          | 7                               | 42             | 4               |            |                |
| 41  |           | Human Interface                  | 9                               | 19                  | 12            | 8                                | 5          | 6                               | 4              | 41              |            | 2              |
| 30  |           | IEEE OTHER                       |                                 |                     |               |                                  |            |                                 |                |                 | 30         |                |
| 12  |           | Reconfigurable                   | 4                               | 4                   | 2             | 4                                | 2          | 4                               |                | 2               |            | 12             |





# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

**SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY**

## Tech OASIS Automated Analyses:

- PCA based factors
- PCA – NO Singular Factor Solution

## PCD Analysis Standardizes PCA

- Maximizes Inclusion of Abstracts in Factors, Number of Factors & Number of High Loading Factor Defining Terms
- Minimizes Abstracts in Multiple Factors

Min/Max Analysis - Analogous to Minimizing Entropy & Maximizing Cohesiveness of Factors

2002-03 Multi-robot PCD Factor Groups & Hi-loading Terms

| # Records | Descriptors                        | Descriptors PCD Groups |                          |                         |                     |                    |                          |                              |                                   |                   |                          |
|-----------|------------------------------------|------------------------|--------------------------|-------------------------|---------------------|--------------------|--------------------------|------------------------------|-----------------------------------|-------------------|--------------------------|
|           |                                    | PCD: *OTHER*           | PCD: multi-robot systems | PCD: Intelligent robots | PCD: Motion control | PCD: sensor fusion | PCD: multi-agent systems | PCD: Control system analysis | PCD: Robustness (control systems) | PCD: Manipulators | PCD: Collision avoidance |
| 23        | multi-agent systems                | 2                      |                          |                         |                     |                    | 1                        |                              |                                   |                   |                          |
| 21        | multi-robot systems                | 2                      | 1                        |                         |                     |                    |                          |                              |                                   |                   |                          |
| 16        | cooperative systems                | 2                      | 1                        |                         |                     |                    |                          |                              |                                   |                   |                          |
| 14        | learning (artificial intelligence) | 2                      |                          |                         |                     | 1                  |                          |                              |                                   |                   |                          |
| 11        | Motion control                     | 2                      |                          |                         | 1                   |                    |                          |                              |                                   |                   |                          |
| 8         | Collision avoidance                | 2                      |                          |                         |                     |                    |                          |                              |                                   |                   | 1                        |
| 7         | Control system analysis            | 2                      |                          |                         |                     |                    |                          | 1                            |                                   |                   |                          |
| 7         | Intelligent robots                 | 2                      |                          | 1                       |                     |                    |                          |                              |                                   |                   |                          |
| 7         | Manipulators                       | 2                      |                          |                         |                     |                    |                          |                              |                                   | 1                 |                          |
| 7         | Robot learning                     | 2                      |                          |                         |                     | 1                  |                          |                              |                                   |                   |                          |
| 6         | Human computer interaction         | 2                      |                          |                         |                     |                    |                          | 1                            |                                   |                   |                          |
| 6         | sensor fusion                      | 2                      |                          |                         | 1                   |                    |                          |                              |                                   |                   |                          |
| 5         | Robot applications                 | 2                      |                          | 1                       |                     |                    |                          |                              |                                   |                   |                          |
| 5         | Robustness (control systems)       | 2                      |                          |                         |                     |                    |                          |                              | 1                                 |                   |                          |
| 5         | System stability                   | 2                      |                          |                         |                     |                    |                          | 1                            |                                   |                   |                          |







# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Expectancy Measure

Likelihood of item in one field having  $T$  or more abstracts in a specific category of a second field.

- Cumulative Binomial Distribution
- Detailed View group size / file size defines success probability  $p$
- Field View item frequency  $n$  times  $p$  defines expected frequency
- Cumulative tail calculation based on whether the Detail View item frequency  $T >$  or  $<$  than expected

If a list item actually occurs  $T$  times in the records common to the records of a second list item and  $T$  is greater than or equal to the expected value, we get:

$$p(X \geq T; n, p) = \sum_{r=T}^n \binom{n}{r} p^r (1-p)^{n-r}$$

Similarly, if  $T$  is less than or equal to the expected value, we get:

$$p(X \leq T; n, p) = \sum_{r=0}^T \binom{n}{r} p^r (1-p)^{n-r}$$







# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Expectancy Measure

Likelihood of item in one field having T or more abstracts in a specific category of a second field.

File Size = 107 abstracts  
Motion Coordination => 46 abstracts  
Probability  $p = 46/107 = .43$

Field View Freq Y = 30  
Expected Freq in Detail View = 13

Observed Detail View Freq = 19

Expectancy Measure = 1 -

$$\left[ p(X \geq T; n, p) = \sum_{r=T}^n \binom{n}{r} p^r (1-p)^{n-r} \right]$$

VantagePoint - [co-op-robot-insp-engi0104-Hierarchy-TS-2002-03]

File Edit View Create Scripts Sheets Window Help

30 Items, 0 Selected

Title

- A cooperative agent model by...
- A distributed motion coordinati...
- A distributed motion coordinati...
- A humanlike grasping force pl...
- A study on foraging behavior ...
- Adaptive desired velocity field...
- An use of reinforcement leami...
- Control method for human-rob...
- Cooperative Behavior Based ...
- Cooperative behavior acquisi...
- Cooperative motion planning f...
- Fuzzy behavior-based control ...
- Guest editorial advances in m...
- Hidden Markov modelling of ...
- Investigation of the impedanc...
- On analysis and control of coll...
- Receiver robot's motion for ha...
- Solving function distribution a...
- Solving function distribution a...
- Some learning methods of co...
- Strategy learning for a team in...
- Swarming robots - collective b...
- Switching control of positionA...
- Team description EIGEN
- The cooperative behavior ac...
- Transportation of an object by...
- Variable impedance control b...
- Variable impedance control wi...
- Variable impedance control wi...
- Whole Body Cooperative Tas...

|    | # Records | # Instances | Country (T) |
|----|-----------|-------------|-------------|
| 1  | 42        | 42          | USA         |
| 2  | 30        | 30          | Japan       |
| 3  | 5         | 5           | Brazil      |
| 4  | 5         | 5           | Italy       |
| 5  | 4         | 4           | China       |
| 6  | 3         | 3           | Singapore   |
| 7  | 2         | 2           | Denmark     |
| 8  | 2         | 2           | France      |
| 9  | 2         | 2           | Germany     |
| 10 | 2         | 2           | UK          |
| 11 | 1         | 1           | Canada      |
| 12 | 1         | 1           | Iran        |
| 13 | 1         | 1           | Philippines |
| 14 | 1         | 1           | Spain       |
| 15 | 1         | 1           | Switzerland |
| 16 | 1         | 1           | Turkey      |

~Raw Record (IEEE MultiRobot Groups)

|    |        |                                  |
|----|--------|----------------------------------|
| 19 | 0.980  | Motion Coordination              |
| 8  | 0.976  | Human Interface                  |
| 6  | 0.661  | Transport Manipulation Grasping  |
| 1  | 0.568  | Reconfigurable                   |
| 5  | 0.470  | Biological                       |
| 3  | 0.459  | Robot Learning                   |
| 3  | -0.439 | IEEE OTHER                       |
| 5  | -0.650 | Localization Mapping Exploration |
| 6  | -0.838 | Communication                    |
| 6  | -0.987 | Architecture Allocation Control  |

Time-Slice Descriptors Comb C BB-PCD Gr

|    |        |                                       |
|----|--------|---------------------------------------|
| 12 | 0.946  | 2002-03: multi-robot systems          |
| 4  | 0.870  | 2002-03: Intelligent robots           |
| 4  | 0.870  | 2002-03: Manipulators                 |
| 5  | 0.645  | 2002-03: Motion control               |
| 9  | 0.481  | 2002-03: multi-agent systems          |
| 2  | -0.391 | 2002-03: Collision avoidance          |
| 2  | -0.468 | 2002-03: Robustness (control systems) |
| 1  | -0.507 | 2002-03: sensor fusion                |
| 2  | -0.608 | 2002-03: Control system analysis      |
| 4  | -0.835 | 2002-03: *OTHER*                      |

For Help, press Ctrl+H

Start [Icons] Microsoft PowerPoint - [...] VantagePoint - [co-o...



# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

**SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY**

## IEEE Multi-robot topic areas

### Expectancy Measure

- Anomaly – Expert Input

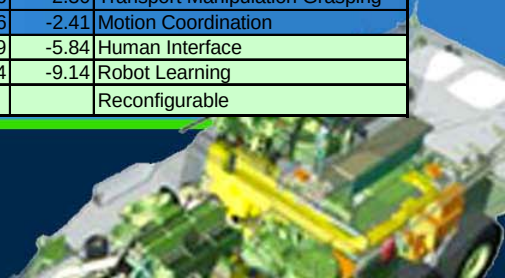
Low < -0.9

- Protect Competitive Advantage IP
- Publication lull prior to patent applications
- Non-active in area

High > 0.9

- Research Focus Area
- Bias result of National Conference in subject area

| Japan Sources |    |        |        |                                  | USA Sources |     |        |        |                                  |
|---------------|----|--------|--------|----------------------------------|-------------|-----|--------|--------|----------------------------------|
| #             | #  | Exp.   | Metric | Cluster Group                    | #           | Grp | Exp.   | Metric | Cluster Group                    |
| 1998-99       |    |        |        |                                  | 1998-99     |     |        |        |                                  |
| 14            | 18 | 0.952  | 4.28   | Human Interface                  | 1           | 1   | 0.79   | 0.79   | Reconfigurable                   |
| 7             | 9  | 0.855  | 3.85   | IEEE OTHER                       | 6           | 18  | 0.757  | 1.14   | Localization Mapping Exploration |
| 12            | 18 | 0.843  | 2.53   | Robot Learning                   | 14          | 50  | 0.741  | 1.03   | Architecture Allocation Control  |
| 8             | 13 | 0.706  | 1.84   | Transport Manipulation Grasping  | 2           | 9   | -0.356 | -1.60  | IEEE OTHER                       |
| 22            | 44 | 0.522  | 1.04   | Communication                    | 3           | 13  | -0.366 | -1.59  | Transport Manipulation Grasping  |
| 9             | 18 | 0.484  | 0.97   | Localization Mapping Exploration | 4           | 18  | -0.42  | -1.89  | Human Interface                  |
| 23            | 50 | -0.573 | -1.25  | Architecture Allocation Control  | 4           | 18  | -0.42  | -1.89  | Robot Learning                   |
| 20            | 54 | -0.926 | -2.50  | Motion Coordination              | 12          | 54  | -0.525 | -2.36  | Motion Coordination              |
| 11            | 34 | -0.927 | -2.87  | Biological                       | 7           | 34  | -0.568 | -2.76  | Biological                       |
|               | 1  |        |        | Reconfigurable                   | 9           | 44  | -0.618 | -3.02  | Communication                    |
| 2000-01       |    |        |        |                                  | 2000-01     |     |        |        |                                  |
| 13            | 39 | 0.956  | 1.43   | Motion Coordination              | 7           | 9   | 0.965  | 4.34   | Reconfigurable                   |
| 4             | 14 | 0.641  | 0.90   | Robot Learning                   | 16          | 38  | 0.768  | 1.33   | Communication                    |
| 3             | 10 | 0.631  | 0.90   | Human Interface                  | 5           | 10  | 0.727  | 1.45   | Human Interface                  |
| 2             | 9  | 0.41   | 0.53   | IEEE OTHER                       | 4           | 9   | 0.61   | 1.10   | IEEE OTHER                       |
| 3             | 14 | -0.359 | -1.68  | Transport Manipulation Grasping  | 4           | 10  | 0.529  | 0.88   | Biological                       |
| 7             | 38 | -0.613 | -3.33  | Communication                    | 7           | 20  | -0.405 | -1.16  | Localization Mapping Exploration |
| 9             | 48 | -0.638 | -3.40  | Architecture Allocation Control  | 4           | 14  | -0.556 | -1.95  | Robot Learning                   |
| 2             | 20 | -0.833 | -8.33  | Localization Mapping Exploration | 15          | 48  | -0.668 | -2.14  | Architecture Allocation Control  |
|               | 10 |        |        | Biological                       | 3           | 14  | -0.742 | -3.46  | Transport Manipulation Grasping  |
|               | 9  |        |        | Reconfigurable                   | 10          | 39  | -0.859 | -3.35  | Motion Coordination              |
| 2002-03       |    |        |        |                                  | 2002-03     |     |        |        |                                  |
| 19            | 46 | 0.98   | 1.67   | Motion Coordination              | 21          | 32  | 0.995  | 2.89   | Communication                    |
| 8             | 13 | 0.976  | 2.54   | Human Interface                  | 20          | 44  | 0.759  | 1.39   | Architecture Allocation Control  |
| 6             | 17 | 0.661  | 1.02   | Transport Manipulation Grasping  | 11          | 23  | 0.718  | 1.38   | Localization Mapping Exploration |
| 1             | 2  | 0.568  | 1.14   | Reconfigurable                   | 4           | 12  | -0.515 | -1.55  | IEEE OTHER                       |
| 5             | 17 | 0.47   | 0.67   | Biological                       | 5           | 17  | -0.676 | -2.30  | Biological                       |
| 3             | 10 | 0.459  | 0.66   | Robot Learning                   | 5           | 17  | -0.676 | -2.30  | Transport Manipulation Grasping  |
| 3             | 12 | -0.439 | -1.76  | IEEE OTHER                       | 15          | 46  | -0.786 | -2.41  | Motion Coordination              |
| 5             | 23 | -0.65  | -2.99  | Localization Mapping Exploration | 2           | 13  | -0.899 | -5.84  | Human Interface                  |
| 6             | 32 | -0.838 | -4.47  | Communication                    | 1           | 10  | -0.914 | -9.14  | Robot Learning                   |
| 6             | 44 | -0.987 | -7.24  | Architecture Allocation Control  | 0           | 2   |        |        | Reconfigurable                   |





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## Tech OASIS PCD Groups

**Expectancy Measure**  
Anomaly – Expert Input

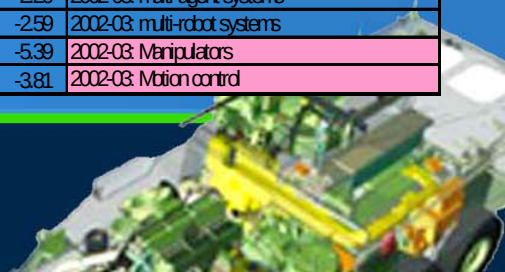
PCD - fewer hi-low  
Expectancy grps

**Holistic Approach – Multi-**  
measure Pervasive Findings

PCD Factor Names change  
over time (e.g., position to  
motion control and adaptive  
control to ... depicting Tech  
Maturity

\*OTHER\*- Non-consensus

| Japan Sources |    |        |        |                                                | USA Sources |    |        |        |                                                |
|---------------|----|--------|--------|------------------------------------------------|-------------|----|--------|--------|------------------------------------------------|
| #             | #  | Exp.   | Metric | Cluster Group                                  | #           | #  | Exp.   | Metric | Cluster Group                                  |
| 11            | 16 | 0.852  | 2.73   | 1998-99: Human computer interaction            | 8           | 16 | 0.971  | 1.94   | 1998-99: real-time systems                     |
| 6             | 10 | 0.643  | 1.61   | 1998-99: Adaptive control systems              | 5           | 12 | 0.853  | 1.46   | 1998-99: Robot learning                        |
| 7             | 12 | 0.636  | 1.53   | 1998-99: Robot learning                        | 4           | 10 | 0.794  | 1.32   | 1998-99: Adaptive control systems              |
| 6             | 11 | 0.554  | 1.22   | 1998-99: Position control                      | 6           | 21 | 0.628  | 0.88   | 1998-99: *OTHER*                               |
| 10            | 21 | -0.443 | -0.93  | 1998-99: *OTHER*                               | 3           | 11 | 0.515  | 0.71   | 1998-99: Position control                      |
| 21            | 44 | -0.478 | -1.00  | 1998-99: learning (artificial intelligence)    | 4           | 16 | 0.471  | 0.63   | 1998-99: Human computer interaction            |
| 12            | 26 | -0.502 | -1.09  | 1998-99: Intelligent control                   | 6           | 26 | -0.414 | -1.79  | 1998-99: Intelligent control                   |
| 6             | 16 | -0.671 | -1.79  | 1998-99: real-time systems                     | 6           | 44 | -0.932 | -6.83  | 1998-99: learning (artificial intelligence)    |
| 18            | 43 | -0.731 | -1.75  | 1998-99: cooperative systems                   | 5           | 43 | -0.966 | -8.31  | 1998-99: cooperative systems                   |
| 5             | 13 | 0.858  | 1.39   | 2000-01: Robot programming                     | 11          | 24 | 0.793  | 1.46   | 2000-01: *OTHER*                               |
| 8             | 25 | 0.847  | 1.25   | 2000-01: Algorithms                            | 6           | 13 | 0.696  | 1.29   | 2000-01: Robot programming                     |
| 6             | 20 | 0.745  | 1.06   | 2000-01: Computer simulation                   | 7           | 20 | -0.405 | -1.16  | 2000-01: Computer simulation                   |
| 8             | 34 | 0.538  | 0.70   | 2000-01: multi-robot systems                   | 10          | 30 | -0.495 | -1.49  | 2000-01: multi-agent systems                   |
| 7             | 30 | 0.517  | 0.67   | 2000-01: multi-agent systems                   | 3           | 12 | -0.62  | -2.48  | 2000-01: Distributed parameter control systems |
| 3             | 12 | 0.511  | 0.68   | 2000-01: Distributed parameter control systems | 5           | 19 | -0.678 | -2.58  | 2000-01: Manipulators                          |
| 4             | 19 | -0.394 | -1.87  | 2000-01: Manipulators                          | 7           | 25 | -0.679 | -2.43  | 2000-01: Algorithms                            |
| 4             | 24 | -0.617 | -3.70  | 2000-01: *OTHER*                               | 9           | 34 | -0.8   | -3.02  | 2000-01: multi-robot systems                   |
| 12            | 27 | 0.946  | 1.70   | 2002-03: multi-robot systems                   | 14          | 24 | 0.93   | 2.23   | 2002-03: *OTHER*                               |
| 4             | 7  | 0.87   | 2.03   | 2002-03: Intelligent robots                    | 5           | 6  | 0.916  | 5.50   | 2002-03: sensor fusion                         |
| 4             | 7  | 0.87   | 2.03   | 2002-03: Manipulators                          | 4           | 11 | -0.436 | -1.20  | 2002-03: Control system analysis               |
| 5             | 14 | 0.645  | 1.00   | 2002-03: Motion control                        | 3           | 9  | -0.475 | -1.43  | 2002-03: Robustness (control systems)          |
| 9             | 31 | 0.481  | 0.68   | 2002-03: multi-agent systems                   | 2           | 7  | -0.524 | -1.83  | 2002-03: Intelligent robots                    |
| 2             | 8  | -0.391 | -1.56  | 2002-03: Collision avoidance                   | 2           | 8  | -0.617 | -2.47  | 2002-03: Collision avoidance                   |
| 2             | 9  | -0.468 | -2.11  | 2002-03: Robustness (control systems)          | 10          | 31 | -0.709 | -2.20  | 2002-03: multi-agent systems                   |
| 1             | 6  | -0.507 | -3.04  | 2002-03: sensor fusion                         | 8           | 27 | -0.768 | -2.59  | 2002-03: multi-robot systems                   |
| 2             | 11 | -0.603 | -3.34  | 2002-03: Control system analysis               | 1           | 7  | -0.77  | -5.39  | 2002-03: Manipulators                          |
| 4             | 24 | -0.835 | -5.01  | 2002-03: *OTHER*                               | 3           | 14 | -0.817 | -3.81  | 2002-03: Motion control                        |



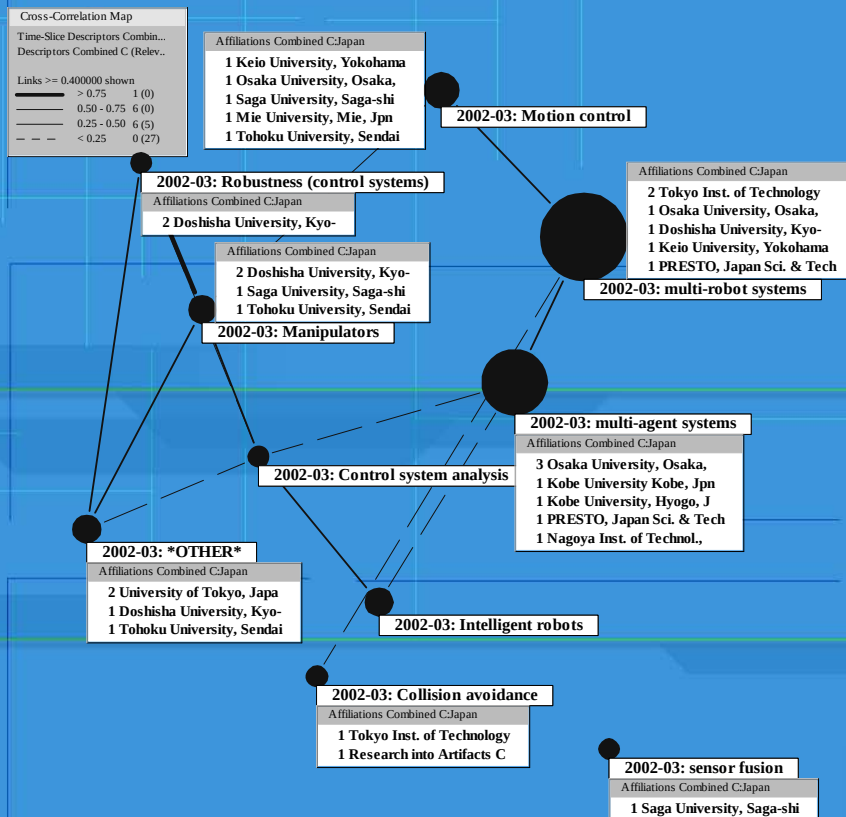




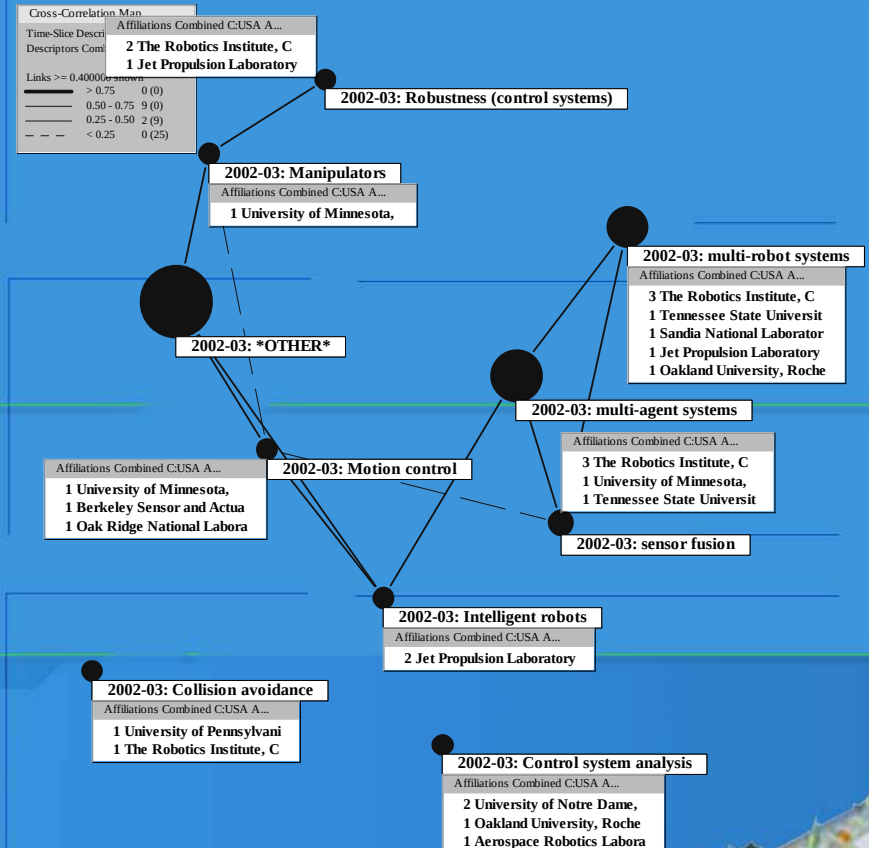
# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Japanese 2002-03 Multi-Robot Research



## USA 2002-03 Multi-Robot Research







# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Observations:

**Expectancy Measure** => Japanese - less emphasis than expected on biological approaches, reconfigurable robots & architecture allocation control (IEEE) and \*OTHER\* (PCD)

=> Japanese - more emphasis than expected on human interface & motion coordination (IEEE) and Multi-robot systems & manipulators (PCD)

=> USA sources – less emphasis than expected on human interface & robot learning (IEEE)

=> USA more emphasis than expected on reconfigurable robots & communication (IEEE) and sensor fusion & \*OTHER\* (PCD)

**Expert Opinion:** Japanese focus more on Industrial Robots and Human Aiding Robots. Must Determine Implications of low \*OTHER\* expectancy.





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SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

## Conclusions & Recommendations

- Overview of **Tech OASIS & Text-Mining Capabilities**
- Analyzed **Field Delimited Data** on Subject of **Multi-Robot Research**
- Approaches for **Segmentation of the data**:
  - **Deductive** (i.e., Expert Perceived) **Categories**
    - ✓ Easier to Use to Generalize Observations over time
    - ✓ Field Experts Understand...Acceptance
    - ✓ But...Bias to Present Time Period
  - **Inductive** (i.e. PCD Derived) **Categories**
    - ✓ Standardizes Analysis
    - ✓ Enables Technology Maturity “Subjective” Assessment
    - ✓ but...Biased by high numbers of low frequency sources of tech papers





# Automated Text Mining Comparison of Japanese and USA Multi-Robot Research

**SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY**

**Expectancy Measure** – Ascertain Topical Emphasis Areas & Identifies Unexpected Patterns....as do other measures

Use **Holistic Approach...Pervasive Patterns...Include Field Experts**

**Tech OASIS / VantagePoint** Automates Clustering / Categorization of Information to Enable and Improve:

- Cognition of Broad Field of Research
- Elicit Research Questions from noted Anomalies
- Promote Innovation through Expert Involvement



<http://www.theVantagePoint.com>

