

Modeling Interactive Agents in ALIVE

Pattie Maes, Bruce Blumberg, Trevor Darrell, Alex Pentland, Alan Wexelblat
MIT Media Laboratory
20 Ames Street
Cambridge, MA 02139
pattie/bruce/trevor/sandy/wex@media.mit.edu

In this video we discuss the design and implementation of a novel system which allows wireless full-body interaction between a human participant and a graphical world inhabited by autonomous agents. The system is called "ALIVE," an acronym for Artificial Life Interactive Video Environment [5]. One of the goals of the ALIVE project is to demonstrate that virtual environments can offer a more emotional and evocative experience by allowing the participant to interact with animated characters which have complex behaviors and which react to the user and the user's actions in the virtual world.

The ALIVE system has been demonstrated and tested in several public forums. It was demonstrated for 5 days at the SIGGRAPH-93 Tomorrow's Realities show in Anaheim, California and for 3 days at the AAAI-94 Art Show in Seattle, Washington. The system is installed permanently at the MIT Media Laboratory in Cambridge, Massachusetts. It will feature in the Ars Electronica Museum, currently under construction in Linz, Austria and the ArcTec electronic arts bienale in Tokyo, Japan, May 1995.

In the style of Myron Krueger's Videoplace system, the ALIVE system offers an unencumbered, full-body interface to a virtual world [4]. The ALIVE user moves around in a space of approximately 16 by 16 feet. A video camera captures the user's image and removes the background environment; thus, no blue-screens or other special walls are needed. The separated outline is then composited into a 3D graphical world. The resulting scene is projected onto a large (approximately 10'x16') screen which faces the user and acts as a "magic mirror:" the user sees him/herself in the environment, surrounded by objects and agents. No goggles, gloves, or tethering wires are needed for interaction with the virtual world.

Computer vision techniques are used to extract information about the person, such as where in the space the person stands and the position of various body parts. A pattern-matching technique called dynamic time-warping is used to recognize simple gestures as they are performed. ALIVE combines active vision and domain knowledge to achieve robust real-time performance [5].

The user's position as well as hand and body gestures are used as input to affect the behavior of agents in the virtual world. Agents have vision sensors which allow them to "see" the user and react to gestures such as

pointing or throwing a virtual ball. The user receives visual (on the big screen) and auditory (prerecorded sound) feedback about the agents' internal state and reactions. Agents have a set of needs and motivations, a set of sensors to perceive their environment, a repertoire of activities which they can perform and a physically-based motor system that allows them to move in and act on the environment. The behavior system decides in real-time which activity the agents should engage in so as to meet their internal needs and to take advantage of opportunities presented by the current state of the environment.

The system allows a direct-manipulation style of interaction in which users interact directly with the environment - such as pushing buttons or moving objects - and also an indirect style of interaction in which users give agents commands and the agents carry out the commands based on the user's input, the current environment, and their internal state. For example, the meaning of a gesture is interpreted by the agents based on the situation the agent and user find themselves in. When the user points away from herself, and thereby "gives the command" to send a character away, the character responding to the command will go to a different place in the virtual environment depending on where the user is standing and which direction she is pointing. In this manner, a relatively small set of gestures can be employed to mean many different things in many different situations.

The ALIVE system incorporates a tool, called "Hamsterdam" [2] [3], for modeling semi-intelligent autonomous agents that can interact with one another and with the user. Hamsterdam produces agents that respond with a relevant activity on every time step, given their internal needs and motivations, their past history and the environment they perceive with its attendant opportunities, challenges and changes. Moreover, the pattern and rhythm of the chosen activities is such that the agents neither dither between multiple activities, nor persist too long in a single activity. They are capable of interrupting a given activity if a more pressing need or an unforeseen opportunity arises.

The Hamsterdam activity model is based on elements taken from animal behavior models initially proposed by ethologists. In particular, several ethological concepts such as behavior hierarchies, releasers, fatigue, and so on have proven to be crucial in guaranteeing the robust and flexible behavior required by autonomous

interacting agents [2] [3].

When using Hamsterdam to build a creature, the designer specifies the sensors of the agent, its motivations or internal needs, and its activities (behaviors) and actions (motor system movements necessary to fulfill a behavior). Given that information, the Hamsterdam software automatically infers which of the activities is most relevant to the agent at a particular moment in time according to the state of the agent, the situation it finds itself in, relevant input from the environment, and its recent behavior history. The observed actions of the agent are the final result of numerous potentially executable behaviors competing for control of the agent. The activities compete on the basis of the value of a given activity to the agent at that instant, given the above factors. The details of the behavior model and a discussion of its features are reported in [2] [3].

The most sophisticated creature built so far is a dog called Silas. Silas's behavioral repertoire currently includes following the user, sitting when asked by the user, going away when ordered by the user to do so, and performing other tricks such as standing on his hind legs, fetching a ball, lying down and shaking paws. Silas also will chase the Hamster if the latter creature is introduced into the same virtual environment as the dog. Along with visual sensors and feedback, the ALIVE environment also uses sound. Silas provides auditory output in the form of a variety of prerecorded samples.

The ALIVE system demonstrates that entertainment and the effort to model believable creatures in simple virtual environments can be a challenging and interesting application area for autonomous agents research. ALIVE provides a novel environment for studying architectures for intelligent autonomous agents. As a testbed for agent architectures, it avoids the problems associated with physical hardware agents or robots, but at the same time forces us to face non-trivial problems, such as noisy sensors and an unpredictable, fast-changing environment. It makes possible our study of agents with higher levels of cognition, without oversimplifying the world in which these agents live.

ALIVE represents only the beginning of a whole range of novel applications that could be explored with this kind of system. We are currently investigating ALIVE for interactive storytelling applications in which the user plays one of the characters in the story and all other characters are artificial agents which collaborate to make the story move forwards (for more exposition on this topic, see the three short papers on ALIVE in fll). Another obvious entertainment application of ALIVE is video games. We have hooked up the ALIVE vision-based interface to existing video game software, so as to let the user control a game with his full body. In addition, we are investigating how autonomous video game characters can learn and improve their competence over time, so as to keep challenging a video game player. Finally, we are modeling animated characters that teach a user a physical skill in a personalized way. The agent is modeled as a personal trainer that demonstrates to the user how to perform an action and provides personalized and timely feedback to the user, on the basis of the sensory information about the user's gestures and body positions. The ALIVE system shows that animated characters that are based on Ar-

tificial Life models can not only look convincing - that is allow suspension of disbelief on viewing - but can act and interact in a realistic enough manner to maintain this suspension of disbelief during unpredictable real-time interaction with users.

Acknowledgements

Alan Wexelblat spent many long hours shooting and editing the video. Thanks Alan!

References

- [1] Joseph Bates, Barbara Hayes-Roth and Pattie Maes, Workshop notes of the AAAI Spring Symposium on Interactive Story Systems: Plot and Character, AAAI, March 1995.
- [2] Bruce Blumberg, "Action Selection in Hamsterdam: Lessons from Ethology", Proceedings of the 3rd International Conference on the Simulation of Adaptive Behavior, Brighton, August 1994, MIT-Press.
- [3] Bruce Blumberg and Tinsley Gallyean, "Multi-Level Direction of Autonomous Creatures for Real-Time Virtual Environments", Proceedings of the Siggraph 1995 conference, Los Angeles, CA, August 1995.
- [4] Krueger M.W., Artificial Reality II, Addison Wesley, 1990.
- [5] Pattie Maes, Trevor Darrell, Bruce Blumberg and Alex Pentland, "The ALIVE system: Full-body Interaction with Autonomous Agents", Proceedings of the Computer Animation '95 Conference, Geneva, Switzerland, IEEE-Press, April 1995.

Author Index

- Adé, Hilde 1201
 Agarwal, Manish 915
 Aha, David W. 384
 Aharoni, Gad 961
 Aloimonos, Yiannis 20
 Anantharaman, Siva 348
 Anderson, Michael 878
 Andre, David 741
 André, Elisabeth 2053
 Aragão, Marcus Poggi de 1862
 Arnold, William C. 985
 Asada, Minoru 126
 Aseltine, Jonathan 1314
 Asher, Nicholas 846
 Azzam, Salha 1354
- Backström, Christer 1599
 Bottcher, Claudia 1728
 Baader, Franz 808
 Bacchus, Fahiem 1933
 Bachmair, Leo 348
 Bala, J. 719
 Ballard, Dana H. 10
 Baluja, Shumeet 133
 Baptiste, Philippe 600
 Barak, Amnon 961
 Baral, Chitta 2017
 Barbeau, M. 791
 Baumgartner, Peter 335
 Bayardo, Roberto J., Jr. 558
 Beek, Peter van 541
 Benferhat, Salem 1449
 Bennett, Scott 1153, 2065
 Bessière, Christian 592
 Bhatia, Praveen 915
 Bhattacharya, Subir 243
 Binder, John 1146
 Birnbaum, Larry 439
 Bistarelli, Stefano 624
 Blocher, Anselm 417
 Blum, Avrim L. 1636
 Blumberg, Bruce 2073
 Bobrow, Daniel 1773
 Bochman, Alexander 1518
 Borgida, Alexander T. 816
 Boström, Henrik 1194
 Boutilier, Craig 1096, 1104, 1550
 Brafman, Ronen J. 96, 1458, 2010
 Branting, L. Karl 384
 Braunschweig, Bertrand 1789
 Bresina, John 1583
 Briggs, Will 688
 Britanik, J. 1677
- Brown, Christopher M. 64
 Bruin, Arie de 273
 Bundy, Alan 175
 Burke, Robin 2071
- Caferra, Ricardo 328
 Cameron-Jones, R. M. 1019
 Cao, Yong 2061
 Carberry, Sandra 1243
 Carbonell, Jaime 2033
 Carenini, Giuseppe 1276
 Cayrol, Claudette 1443
 Cha, Byungki 304
 Chabin, Jacques 348
 Chander, Ishwar 1390
 Chatterjee, Shankar 2063
 Chaudhri, Vinay K. 759
 Chen, Pang C. 252
 Chen, Ta 348
 Chess, David M. 985
 Chumura, Fumihiko 259
 Chopra, Rajiv 50
 Chouery, Berthe Y. 1694
 Chu-Carroll, Jennifer 1243
 Cohen, Robin 1338
 Collins, Gregg 439, 1567
 Cook, Diane 688
 Cooper, Paul R. 2051
 Crawford, James M. 1814
- Daniels, Jody J. 400
 Darrell, Trevor 2073
 Darwiche, Adnan 211
 Davidor, Yuval 961
 Davlouros, James D. 2059
 DeJong, Gerald 1153, 2065
 DeJong, K. 719
 Dean, Thomas 1121
 Dearden, Richard 1104
 Dechter, Rina 572, 616, 1742, 2027
 Degtyarev, Anatoh 342
 Delgrande, James P. 1488
 Demri, Stéphane 289
 Denecker, Marc 1201
 Deng, Kan 1233
 De Raedt, Luc 432
 Dietterich, Thomas G. 1114
 Doherty, Patrick 1502
 Domingos, Pedro 1226
 Dorr, Bonnie J. 1299
 Doyle, Richard J. 1821
 Drummond, Mark 1583
 Dubois, Didier 1449, 1924
 Durrant-Whyre, Hugh 36
- Duxbury-Smith, Peter 1757
 Dvorak, Daniel L. 1814
- Edward Tsang 2027
 Eiter, Thomas 870
 Eklundh, Jan-Olof 27
 El Fattah, Youssi 1742
 Ephrati, Ethan 679
 Epstein, Susan L. 454
 Frol, Kutluhan 1592
 Etzioni, Oren 930, 1704
 Euzenat, Jérôme 894
 Everett, John O. 1837
- Falkenhainer, Brian 1798
 Faloutsos, Boi 1694, 1757, 2055
 Farguet, Hélène 631
 Farquhar, Adam 1773, Adam 1806
 Fayyad, Usama M. 2067
 Ferguson, Innes A. 2059
 Fermüller, Cornelia 20
 Fink, Eugene 1606
 Finkler, Wolfgang 2053
 Firby, R. James 72
 Fischer, Markus 1398
 Fisher, David 1314
 Fisher, Doug 1041
 Foo, Norman 822
 Forbes, Jeff 1878
 Forbus, Kenneth D. 1798
 Ford, Kenneth 972
 Fox, Susan 391
 Frohlich, Peter 1721
 Freuder, Eugene C. 548, 563, 592, 2027
 Friedman, Nir 1458
 Frisch, Alan M. 1210
 Frost, Daniel 572
 Fu, Daniel D. 464
 Fu, Yongjian 2049
 Furbach, Ulrich 335
 Furse, Edmund 2057
 Furst, Merrick L. 1636
- Gorz, Gunther 73
 Gaasterland, Terry 1299
 Gamper, Johann 784
 Geffner, Héctor 1495
 Georgeff, Michael P. 704
 Getoor, Lise C. 1612
 Ghallab, Malik 1643
 Giacomo, Giuseppe De 801
 Ginsberg, Matthew L. 607, 2027
- Giller, Daniel 961
 Grunichiga, Enrico 1964
 Gluck, Mark 518
 Godo, Lluís 1916
 Gogic, Goran 862
 Goldszmidt, Moisés 1104
 Goller, Christoph 509
 Gottlob, Georg 870
 Graf, Winfried 2053
 Grant, Stuart A. 646
 Greiner, Russell 1162, 1169
 Grigni, Michelangelo 901
 Gruber, Tom 768
 Gupta, Satyandra K. 1670
 Gupta, Vineet 1773
- Haase, Kenneth B. 1375
 Haines, Matthew 1390
 Halpern, Joseph Y. 1853, 1933
 Hamidzadeh, Babak 220
 Hammond, Kristian J. 464, 2071
 Han, Jiawei 2049
 Hansen, Pierre 1862
 Harada, Larry 672
 Harbusch, Karin 2053
 Harrison, Robert F. 488
 Hartley, Anthony 1398
 Harvey, William D. 607
 Hasegawa, Osamu 82
 Hatzivassiloglou, Vasileios 1382, 1390
 Hayamizu, Satoru 82
 Hayashi, Yoshihiko 1711
 Hayes, Patrick 972
 Hayes-Roth, Barbara 967
 Hearst, Marti A. 2047
 Heinsohn, Jochen 2053
 Hendler, James 142, 1592, 2033
 Herrmann, Christoph S. 494
 Hogg, Tad 711
 Holder, Lawrence B. 1056
 Horswill, Ian 56
 Hovy, Eduard 1390
 Howe, Adele E. 1620
 Hozumi, Tanaka 1308
 Huang, J. 719
 Huang, Tim 1878
 Hubbe, Paul D. 548
 Hunt, Sebastian 640
 Huntet, Edward 2063
- Iida, Masayo 1390
 Ikeda, Mitsuru 1830
 Imaichi, Osamu 1435

- Inoue, Katsumi 204
 Isbell, Charles 2045
 Itou, Katsunobu 82
 Iwama, Kazuo 304
 Iwasaki, Yumi 885, 1773, 1806
 Iwayama, Makoro 1322
- Jönsson, Arne 1405
 Jaeger, Manfred 1847
 Jain, Ramesh 2063
 Jameson, Anthony 1886
 Jampel, Michael 640
 Japkowicz, Nathalie 518
 Jaumard, Brigitte 1862
 Jonsson, Peter 1599
 Jung, Bernhard 2061
 Junker, Ulrich 1789
- Kabanza, F. 791
 Kahn, Roger E. 72
 Kaindl, Hermann 236
 Kainz, Gerhard 236
 Kambhampati, Subbarao 1627
 Kanazawa, Keiji 1146, 1878
 Kang, Hee-Joong 1130
 Karp, Peter D. 751, 768
 Kartha, G. Neelakantan 1970
 Kashino, Kunio 158
 Kask, Kalev 616
 Katkere, Arun 2063
 Kautz, Henry 862
 Kawabata, Takeshi 165
 Kay, Judy 978
 Keane, Mark T. 377
 Kelly, Patrick 2063
 Kennedy, R. Lee 488
 Kephart, Jeffrey O. 985
 Khardon, Roni 319
 Kilger, Anne 2053
 Kim, Jin H. 1130
 Kinoshita, Tomoyoshi 158
 Kitamura, Yoshinobu 1830
 Kitano, Hiroaki 532
 de Kleer, Johan 1736
 Knight, Kevin 1382, 1390
 Knight, Leslie 725
 Knoblock, Craig A. 1686
 Koenig, Sven 1080, 1660
 Kohavi, Ron 1071, 1137
 Kolbe, Thomas 190
 Koller, Daphne 1146, 1185, 1853
 Kondrak, Grzegorz 541
 Kononenko, Igor 1034
 Korf, Richard E. 266
 Koza, John R. 734
 Kozato, Fukumi 502
 Kraus, Sarit 655
 Krieger, Hans-Ulrich 1428
 Krishnaprasad, P. S. 142
 Krotkov, Eric 88
- Krulwich, Bruce 439
 Kuokka, Daniel 672
 Kuramura, Don 2063
 Kurita, Takio 82
 Kurumatani, Koichi 1750
- Laborie, Philippe 1643
 Lakemeyer, Gerhard 853
 Lansky, Amy L. 1612
 Larrosa, Javier 579
 Laux, Armin 808
 Law, Kincho 885
 Leake, David B. 391
 Leeb, Angelika 236
 Lehmann, Daniel 1534
 Lehnert, Wendy 1050, 1314
 Lenat, Douglas 2033
 Lenzerini, Maurizio 801
 Leone, Nicola 870
 Lesh, Neal 1704
 Lesser, Victor R. 662, 694
 Levesque, Hector J. 1933
 Levy, Alon Y. 196
 Li, Chia-Hsin 1071
 Li, Xiaobin 1368
 Liberatore, Paolo 1557
 Lieberman, Henry 924
 Lifschitz, Vladimir 1964, 1970
 Lin, Dekang 1420
 Lin, Fangzhen 1985, 2001
 Lin, Shieu-Hong 1121
 Linden, Keith Vander 1398
 Ling, Sui-ky Ringo 1766
 Litman, Diane J. 1814
 Liu, Bing 119, 586
 Liu, Huan 480
 Llopis, Jimena 1495
 Lochbaum, Karen E. 1260
 Lombart, Vincent 175
 Luk, Steve K. 1390
 Lukaszewicz, Witold 1502, 1950
 Lytinen, Steven L. 2071
- Méndez, Gisela 1495
 Ma, Zhe 488
 Maclin, Richard 524
 Madalinska-Bugaj, Ewa 1950
 Maes, Pattie 2073
 Makoto, Iwayama 1308
 Manikonda, Vikram 142
 Maples, Creve 2069
 Marchiori, Elena 356
 Marefat, M. 1677
 Maresky, Jonathan 961
 Marquis, Pierre 837
 Matsumoto, Yuji 1435
 Mattis, Joe 1276
 Matwin, Stan 1368
 McCain, Norman 1978
 McCarthy, John 2041
- McCarthy, Joseph E. 1050
 McCartney, Robert 878
 McConachy, Richard 1251
 McGuinness, Deborah L. 816, 2045
 Melis, Erica 182
 Meseguer, Pedro 579
 Mikitiuk, Artur 1509
 Miranker, Daniel P. 558
 Mishra, Anil K. 1814
 Mitchell, Tom M. 1217
 Mittal, Vibhu O. 1276
 Miyashita, Kazuo 371
 Mizoguchi, Riichiro 1830, 2033
 Moezzi, Saied 2063
 Montanari, Ugo 624
 Moore, Andrew W. 1233
 Moore, Johanna D. 1276
 Morreau, Michael 1466
 Mouaddib, Abdel-illah 775
 Muggleton, Stephen 997
 Mukerjee, Amitabha 915
 Murthy, Sreerama 1025
 Myers, Catherine 518
 Myers, Karen L. 768
 Mylopoulos, John 759
- Nagao, Karashi 1284
 Nakadai, Kazuhiro 158
 Nakamura, Takayuki 126
 Nakatani, Tomohiro 165
 Nasukawa, Tetsuya 1360
 Nau, Dana S. 1592, 1670
 Nayak, P. Pandurang 196
 Nebel, Bernhard 2053
 Nejdil, Wolfgang 784, 1721
 Nguetsé, Guy-Blaise Douanya 1862
 Niemelä, Ilkka 312
 Nishida, Toyooki 42
 Niyogi, Sourabh A. 3
- Okuno, Hiroshi G. 165
 Ortega, Julio 1041
 Otsu, Nobuyuki 82
- Page, C. David, Jr. 1210
 Pagnucco, Maurice 822
 Paley, Suzanne M. 751
 Papadias, Dimitris 901
 Papadimitriou, Christos 862, 901
 Pape, Claude Le 600
 Paris, Cécile 1398
 Parr, Ronald 1088
 Passonneau, Rebecca J. 1267
 Patel-Schneider, Peter F. 1814
 Pearl, Judea 1480
 Pederson, Jan O. 2047
 Peltier, Nicolas 328
 Pemberton, Joseph C. 227
- Pemberton, Lyn 1398
 Pentland, Alex 2073
 Perkowitz, Mike 930
 Peterson, Craig 2069
 Pfeffer, Avi 1185
 Pijls, Wim 273
 Plaat, Aske 273
 Pollack, Martha E. 679
 Pomerleau, Dean A. 133
 Poole, David 150
 Power, Richard 1398
 Prade, Henri 1449, 1924
 Profitlich, Hans-Jürgen 2053
 Prokopowicz, Peter N. 72, 2051
 Pryor, Louise 1567
 Puterman, Martin L. 1096
- Quinlan, J. R. 1019
- Régin, Jean-Charles 592
 Raiman, Olivier 1736
 Ramakrishnan, I. V. 348
 Ramoni, Marco 1869
 Rao, Anand S. 704
 Rao, Rajesh P. N. 10
 Reece, Steven 36
 Regli, William C. 1670
 Reiter, Ray 2001
 Rekimoto, Jun 1284
 Resnick, Lori Alperin 2045
 Resnik, Philip 448
 Richards, Bradley 1757
 Rintanen, Jussi 1474
 Rissland, Edwina L. 400
 Rist, Thomas 2053
 Rosenbloom, Paul 103, 2033
 Rossi, Francesca 624
 Roth, Dan 319, 1178
 Roth, Steven 1276
 Russell, Stuart 950, 1088, 1146, 1878
- Sablon, Gunther 432
 Sakama, Chiaki 204
 Salzberg, Steven 1025
 Samuelsson, Christer 1414
 Sanders, Kathryn E. 408
 Sandholm, Tuomas W. 662, 694
 Saraswat, Vijay 1773
 Sasajima, Munchiko 1830
 Sasaki, Takahiro 259
 Schäfer, Ralph 1886
 Schäfer, Ulrich 1428
 Schaeffer, Jonathan 273
 Schaefer, Marco 1557
 Schiex, Thomas 631
 Schirra, Jörg R. J. 417
 Schroeder, Michael 1721
 Schuurmans, Dale 1169
 Schweitzer, Haim 908
 Scott, Donia 1398

Selman, Bare 862, 998, 2027
 Sen, Sandip 725
 Setiono, Rudy 480
 Shavlik, Judc'w. 524
 Shchory, Onn 655
 Shekhar, Shashi 220
 Shoham, Yoav 96
 Simmons, Rcid 1660, 1080
 Simon, Hrberr A. 939
 Simons, Joep 1886
 Sims, Brailey 822
 Sloman, Aaron 2037
 Smetana, Harald 236
 Smets, Philippe 1896
 Smith, Barbara M. 646
 Smyrh, Barry 377
 Soderland, Stephen 1314
 Song, Fei 1338
 Sorkin, Gregory B. 985
 Spala7.zi, Luca 1941
 Sperduti, Alessandro 509
 Srihari, Rohini K. 50
 Srinivasan, Raghavan 1620
 St-Henis, R. 791
 Sranca, Amonina 509
 Steedman, Mark 1292
 Srent/, Anthony 1652
 Srolzenburg, Fricdcr 335
 Straach, Janell 908
 Sun, Kun 2055
 Sun, Ron 424
 Swain, Michael J. 72, 464
 Swanberg, Deborah 2063
 Swanson, Keith 1583
 Sycara, Katia 371
 Szalas, Andrzej 1502
 Szpakowicz, Stan 1368
 Tai, Li-Cheng 2063
 Takenobu, Tokunaga 1308
 Tambe, Milind 103
 Tan, Sek-Wah 1480
 Fan, Yao-Hua 1525
 Tanaka, Hidehiko 158
 lanaka, Ka/uyo 82
 Tang, Simon 2049
 Tani, Jun 112
 Tenncnholtz, Moshe 2010
 Tei7opoulos, Demctri 1003
 Tcsauro, Gerald J. 985
 Tessler, Shirley 885
 Thielschr, Michael 1956, 1994
 l'hiiin, Sebastian 1217
 Tokoro, Mano 259
 Tokunaga, Takenobu 1322
 van der Torre, Lccndert W. N. 1525
 de la Tour, Thierry Boy 289
 Traversa, Paolo 1941
 Truszczynski, Mirosław 1509
 Tsuneto, Rciko 1592
 Turk, Andreas 473
 Turner, Hudson 1978
 Uhlin, Ibmas 27
 Ur, Sigatit 679
 Uramoto, Nanhiko 1^60
 Vafale, H. 719
 del Val, Alvaro 830
 Vertaillic, Gerard 631
 Verma, Rakesh M. 362
 Vescovi, Marcos 1806
 Vieu, Laure 846
 Vila, Uu,^, 1916
 Vilain, Marc 1346
 Voronkov, Andrei ^42
 Wachsmuth, Ipke 2061
 Wakimoto, Kop 206^
 Wallace, Richard J. 563
 Walihcr, Chmtoph 190
 Weehsler, H. 719
 Wcigel, Rainer 1694
 Weis,'Fhomas 1886
 Wcxelblai, Alan 2073
 While, Steve R. 985
 Whitney, Richard 1390
 Williams, Mary-Anne 822, 154
 Wusniewski, Robert W. 64
 Wu, Dekai 1328
 Xiaochun, Cheng 1910
 Xuhua, Liu 1910
 Yager, Ronald R. 1902
 Yamada, Kenji 1390
 Yamamoto, Ka/uhiko 82
 Yang, Qiang 1606
 Yip, Kenneth 1782
 Yugami, Nobuhiro 282
 Yunfei, Jiang 1910
 Zhang, Hanrao 298
 /hang, Jian 298
 Zhang. Wei 1114
 Zhao, Qi 42
 Zheng, Zijian 1064
 Zilberstein, Shlomo 775, 1576
 Zukeiman, Ingrid 1251