Final Report on the IAU Symposium n. 325
Astroinformatics
Sorrento (Italy) October 20-25, 2016-12-08

Report submitted by
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1. Organizing Committees and proceedings

The SOC was chaired by: Giuseppe Longo (I), Eduardo Vera (Chile), George S. Djorgovski (USA) and J. Van der Plas (USA)

Other members of the SOC were: Pablo Estevez (Chile), Eric Feigelson (USA), Alyssa Goodman (USA), George Lake (CH), Erzsébet Merenyi (USA), Fion Murtagh (USA), Viktor Pankratius (USA), Susanne Staggs (USA), Alex Szalay (USA), Ricardo Vilalta (USA), Dejan Vinkovic (HR).
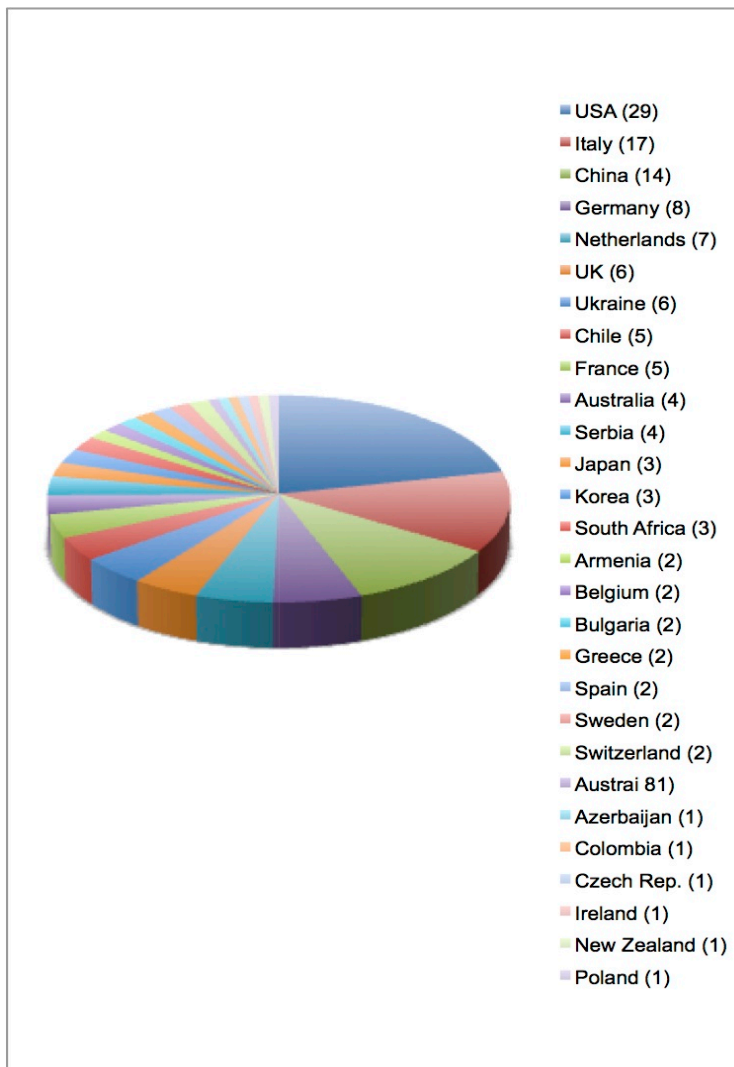
The LOC was chaired by Massimo Brescia (INAF – I) and formed by: Civita Vellucci, Demetra De Cicco, Arianna Cavallo, Stefano Cavuoti plus many students from the local University

At the moment this report is written, the proceedings are being collected and refereed. Main editor is Massimo Brescia. Co-editors are S. Cavuoti, S.G. Djorgovski, E. Feigelson and G. Longo.

2. Gender and Country distribution

As it could be expected, the field presents a gender issue since it results from the fusion of research fields which have been historically male dominated. It was, however, a pleasant surprise that this unfortunate situation is improving and that a fair (but still small) number of women is entering the arena. In comparison to previous Astroinformatics meetings, the Symposium has seen a much larger participation of women. The SOC made an effort to promote the participation of women by giving them higher priority in the allocation of IAU grants and also by inviting -whereas possible- outstanding female colleagues to give invited talks.

The Symposium has seen the participation of scientists from 28 countries.

- USA (29)
- Italy (17)
- China (14)
- Germany (8)
- Netherlands (7)
- UK (6)
- Ukraine (6)
- Chile (5)
- France (5)
- Australia (4)
- Serbia (4)
- Japan (3)
- Korea (3)
- South Africa (3)
- Armenia (2)
- Belgium (2)
- Bulgaria (2)
- Greece (2)
- Spain (2)
- Sweden (2)
- Switzerland (2)
- Austrai 81)
- Azerbaijan (1)
- Colombia (1)
- Czech Rep. (1)
- Ireland (1)
- New Zealand (1)
- Poland (1)

Distribution of participating countries (within brackets the number of participants)

The meeting was attended by 135 people (107 men and 28 women) and – both in terms of attendance and of contents – will become a milestone in the development of the emerging field of Astroinformatics. To quote just a few facts: in comparison with the previous, most

successful astroinformatics meetings, the attendance has more than doubled and the number of countries represented has largely increased (by a factor of three).

3. Generalities

The main information about the Symposium can be found on the web site:
1. Generalities: http://dame.dsf.unina.it/astroinformatics2016.html
2. Program: http://dame.dsf.unina.it/astroinformatics2016/program.html
3. Committees: http://dame.dsf.unina.it/astroinformatics2016/socloc.html
4. Participants: http://dame.dsf.unina.it/astroinformatics2016/participants.html
Some of this information is also in the attached files.

The meeting was sponsored by IAU (through grants), the Department of Physics University of Napoli Federico II, the Italian National Institute of Nuclear Physics, the Italian National Institute of Astrophysics, Microsoft Research, and the Municipality of Sorrento. The last two sponsored the social event (concert plus social banquet). The meeting was widely followed on Twitter (hashtags: #astroinfo2016, #astro2016). The IEEE chapter for Computational Intelligence sponsored the welcome cocktail. The meeting was co-sponsored also by the European COST Action TD-1406, which organized a follow-up meeting (25-26 of October) immediately after the conclusion of the main event.

Some pictures taken during the concert and the social banquet

The Municipality also sponsored a public lecture held in the main hall of the townhouse. The speaker was Prof. Massimo Capaccioli, emeritus at the University Federico II and former president of the Italian Astronomical Society, and the topic was "The Future of Astronomy and the data deluge". More than 200 people attended the lecture (mainly students from the local high schools) which was very succesful.

Both the symposium and the public lecture were advertised and followed on the local and national press (in a dozen of articles).

The public lecture by Prof. M. Capaccioli

4. Scientific Program

The Symposium was structured in 19 invited talhs (30 min), 20 contributed (15 min) talks, and 4 discussion panels as it is detailed in the attached program. In the discussion panels some of the session speakers were asked to debate the most relevant topics emerged during the presentations with the audience. Some of these discussions turned out to be more interesting than the presentation themselves.

48 posters were on display in the hall adjacent to the lecture hall where also the coffee breaks were served (in order to maximize the exposition of the posters to the participants). Only one invited talk was given via Skype (S. Doeleman). Posters were presented (two slide presentation) to the audience in a dedicated poster session.

The sessions (some of them lasted longer and were split in several parts) focused on:
- Current and Future Surveys
- Time Domain and Cosmology
- Data Visualization
- Interdisciplinary Connections and Machine Learning
- Astroinformatics Projects

Sessions slots were chaired by: Erzsébet Merenyi, Ray Norris, Francesca delle Ore, George S. Djorgovski, Kai Polsterer, Matthew Graham, Massimo Brescia, Areg Mikhaelian, Pierre Dubath, Thijs van der Hulst.

5. General comments and Summary

IAU Symposium n. 325 on Astroinformatics brought together world-class experts to address the methodological and technological challenges posed by the scientific exploitation of massive data sets produced by the new generation of telescopes and observatories. Astronomy, which already was at the forefront of Big Data science with exponentially growing data volumes and data rates, is now entering the petascale regime at optical, infrared and radio wavelengths.
Astronomy is truly becoming data-driven in the ways that are both quantitatively and qualitatively different from the past. The data structures are not simple, and the procedures to gain astrophysical insights are not obvious, but the informational content of the modern data sets is so high that archival research and data mining are not merely profitable, but

practically obligatory, since researchers who obtain the data can only extract a small fraction of the science that is enabled by it.

The symposium took place at a crucial stage in the development of this new field of research, when many efforts have made significant achievements, but the widespread groups have not yet effectively communicated across specialties, gathered to assimilate their achievements, and consulted with cross-disciplinary experts. By bringing together astronomers involved in survey and large simulation projects, computer scientists, data scientists and companies, the symposium has provided an unique environment for the exchange of ideas, methods, software, and technical capabilities, seeking to establish enduring associations between the diverse researchers.

The first meeting where computer scientists and astronomers gathered to discuss how to cope with the astronomical data deluge expected from a new generation of telescopes and sensors, was held in Pasadena in 2000. This meeting followed the publication of the NSF Decadal Survey, which recommended the implementation of a world wide virtual organization, aimed at making all astronomical data and computational infrastructures available to a large distributed community of users. This meeting stemmed a large international effort aimed at the construction of the so called Virtual Observatory (VO). In the following decade, the VO produced an impressive amount of standards for data storage and interoperability, as well as many tools which allowed a more effective access and usage of distributed astronomical data. In year 2010 it became clear that –in order to complete the VO vision- there was the need for an alternative "bottom-up" approach focused more on the implementation of advanced tools for data mining rather than on standardization and interoperability. This lead to the Astroinformatics workshop series run on an yearly basis (2010 Pasadena, 2011 Sorrento, 2012 Redmond, 2013 Sidney, 2014 Valparaiso, 2015 Dubrovnik). During these meetings for the first time astronomers, computer scientists and experts form other disciplines were put together to sistematically exchange experiences, establish a common language and to start joint projects. The IAU Symposium 325 on Astroinformatics (also Astroinformatics 2016) has marked the culmination of this process and has demonstrated that Astroinformatics has become a new and vibrant field of research, indispensable to allow the scientific exploitation of the huge data sets and data streams produced by the new instruments.

During the Symposium it clearly emerged that the most challenging problems to be faced, are not posed by the computational infrastructures, which – at least for the majority of the problems – seem to evolve at the needed pace, but rather by the size and complexity of a parameter space which, in the case of panchromatic studies, can number several hundreds of dimensions (very sparsely populated). Different approaches related to feature selection, missing data and data visualization have been widely discussed taking also in account solutions adopted in other fields such as remote sensing and sensor networks.

6. Scientific highlights

IAU Symposium 325 has been held at a time when many survey projects producing large amounts of data are either being completed (e.g. PANSTARRS, CRTS, KiDS, GAIA etc.) or being planned (e.g. Event Horizon Telescope, LSST, Euclid), thus causing an ever increasing need for innovative software and hardware solutions. During the meeting, the present status of the various projects was summarized and the planned future developments outlined.

1. The current status of several survey projects (LSST, Euclid, etc) has been updated and some common problems have emerged. These problems will require a common solution such as: optimal extraction of features (see below),
2. Optimal extraction of features. This issue has been debated in many talks and posters. The parameter space covered by modern multi-wavelength surveys is of very high dimensionality and, given the poor scalability of many data mining algorithms, feature selection (i.e. the identification of the optimal number of parameters needed to perform a specific task) is crucial. Several approaches have been presented and discussed.
3. Estimation of errors (PDF's) with Machine Learning methods. A lively discussion was started and still goes on among different groups who attended the meeting. Work is in progress.
4. Classification problems. The availability of new, complex data sets allows to apply suvervised classification methods to new problems. For the first time it was

presented a successful application of these methods to the classification of X-ray and gamma.ray sources. The same methods were also applied to the classification of SN subtypes and to stellar spectra.

5. It clearly emerged the large amount of work which is currently ongoing in the field of automatic classification of transients. The first interesting results on the detection of quasars via temporal variability were discussed.

6. Scalability of ML algorithms. In many applications it clearly emerged the need for faster algorithms and/or for the parallel implementation of old ones. Some interesting examples were presented and discussed in various cases:

7. Many new methods –originating from other scientific communities but potentially of great value for astronomical applications- were presented and collaborations were established to explore their application to specific astronomical problems (evaluation of photometric redshifts and automatic identification of periodic signals).

8. Very interesting were also the first results obtained using a pure "data driven approach" were the role played by human operators is reduced to a minimum and the data analysis is performed by the machines without or with limited a-priori information. These results suggest the need for a redefinition of the way in which physical quantities (such as fluxes, etc.) need to be measured in order to optimize the performances of automatic methods.

7. The Participants

In spite of the relative novelty the field, the Symposium attracted a vibrant crowd of 135 participants.

First name	last name	Institute
Andreas	Alamanos	Dept. of Informatics, Ionian University, Greece
Walter	Alef	Max Planck Institute for Radio Astronomy, Germany
Jovan	Aleksic	Astronomical Observatory of Belgrade (Serbia)
Rupert	Allison	University of Cambridge (UK)
Valeria	Amaro	Dept. of Physics - University Federico II, Napoli (I)
Matteo	Bachetti	INAF - OA Cagliari (I)
Ji-Hye	Baek	Korea Astronomy and Space Science Institute (Korea)
Zhongrui	Bai	National Astronomical Observatories, Chinese Academy of Sciences (China)
Aneta	Baloyan	Byurakan Astrophysical Observatory (Armenia)
Graham	Barnes	NWRA (Australia)
Jim	Barrett	University of Birmingham, UK
Sudhanshu	Barway	South African Astronomical Observatory (SAAO- South Africa)
Michael	Biehl	University of Groningen (NL)
Lucas Axel	Bignone	IAFE (UBA/CONICET)
Sergi	Blanco-Cuaresma	University of Geneva (CH)
David	Borncamp	Space Telescope Science Institute (USA)
Olga	Botygina	Astronomical Observatory of the Taras Shevchenko National University of Kyiv (Ukraine)
Matthew	Bourque	Space Telescope Science Institute, Baltimore, Maryland, USA
Carlos Henrique	Brandt	La Sapienza University of Rome

Maarten	Breddels	University of Groningen, The Netherlands
Massimo	Brescia	INAF - Capodimonte Astronomical Observatory
Fernando	Caro	GEPI - Observatoire de Paris
Stefano	Cavuoti	INAF - Capodimonte Astronomical Observatory
Rossella	Consiglio	Università Federico II, Italy
Kenneth	Chambers	Institute for Astronomy University of Hawaii
Dan	Crichton	NASA Jet Propulsion Laboratory, USA
Antonio	D'Isanto	Heidelberg Institute for Theoretical Studies - HITS
Cristina	Dalle Ore	USRA - Lunar and Planetary Institute, USA
Pilar	de Teodoro	European Space Agency
Demetra	De Cicco	University Federico II, Italia
Andrie	De Vries	Microsoft Corporation
George	Djorgovski	California Institute of Technology, Pasadena CA, USA
Shep	Doeleman	MIT Haystack Observatory (remote participation)
Fuqing	Duan	Beijing Normal University,CHINA
Pierre	Dubath	University of Geneva, Switzerland
Felipe	Elorrieta	Pontificia Universidad Católica de Chile
Pablo	Estevez	University of Chile
Susana	Eyheramendy	Pontificia Universidad Catolica de Chile
Elena	Fedorova	National Taras Shevchenko University of Kiev, Astronomical Observatory
Eric	Feigelson	Pennsylvania State University, USA
Qi	Feng	McGill University
Francisco	Forster	Center for Mathematical Modelling and Millennium Institute of Astrophysics Universidad de Chile
Emmanuel	Gangler	LPC - Universite' Blaise Pascal, France
Jorge Enrique	Garcia Farieta	Universidad Nacional de Colombia
Mauro	Garofalo	University Federico II, Napoli
Fabio	Gastaldello	INAF-IASF Milan
Panagiotis	Gavras	IAASARS, National Observatory of Athens
Nikos	Gianniotis	Heidelberg Institute for Theoretical Studies
Carlos Alberto Gomez	Gonzalez	University of Liege, Belgium
Alyssa	Goodman	Harvard-Smithsonian CFA, USA
Matthew	Graham	California Institute of Technology, Pasadena CA, USA
Andy	Green	Australian Astronomical Observatory
Steve	Groom	IPAC, California Institute of Technology, USA
Rustam	Guliyev	Shamakhy Astrophysical Observatory
Ping	Guo	Beijing Normal University
Ahmed Abdel	Hady	Astronomy, space and Meteorology Dept., Cairo University
Hasitieer	Haerken	Beijing Normal University
Jeremy	Hare	The George Washington University
Sheida	Hassani	Sharif University of Technology

Sara	Heap	NASA/Goddard, USA
Nina	Hernitschek	Max Planck Institute for Astronomy, Heidelberg, Germany
Alisher S.	Hojaev	NUU-UBAI
Maohai	Huang	National Astronomical Observatories, Chinese Academy of Sciences
Pablo	Huijse	Millennium Institute of Astrophysics Universidad de Chile
Alin	Kalam	Vienna University
Jeff	Kern	National Radio Astronomy Observatory
Sergii	Khlamov	Kharkiv National University of Radioelectronics, Department of Electronic computer
Johan	Knapen	Instituto de Astrofisica de Canarias, Spain
Svitlana	Kolomiyets	Kharkiv National University of Radio Electronics, Ukraine
Irina	Kovalenko	IMCCE/LESIA Paris Observatory
Michael	Kurtz	CFA Harvard
Emille	Ishida	University Blaise Pascal
Tomoaky	Ishiyama	Institute of Management and Information Technologies, Chiba University, Japan
Zeljko	Ivezic	University of Washington, USA
Darko	Jevremovic	Astronomical Observatory Belgrade
Changhua	Li	National Astronomical Observatories, Chinese Academy of Sciences
Zhou	Lixiao	National Astronomical Observatories, Chinese Academy of Sciences
Giuseppe	Longo	Dept. of Physics - University Federico II, Napoli
Andrea	Longobardo	INAF IAPS, Italy
Stephen	Lubow	Space Telescope Science Institute
Vesna	Lukic	Hamburger Sternwarte, Germany
Ashish	Mahabal	California Institute of Technology, Pasadena CA, USA
Abhishek	Malali	Harvard University, USA
Joseph M.	Mazzarella	California Institute of Technology, Pasadena CA, USA
Erzsébet	Merényi	Rice University, Houston, TX USA
Areg M.	Mickaelian	Byurakan Astrophysical Observatory (BAO)
Sergio	Molinari	INAF, IAPS, Rome, Italy
Moein	Mosleh	Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
Christian	Muller	Belgian Users Support and Operation Centre
Fionn	Murtagh	Goldsmiths University of London, GB
Nicola	Napolitano	INAF - Astronomical Observatory of Capodimonte
Sara	Nieto Rodriguez	European Space Agency
Ray	Norris	Australia Telescope National Facility
Michael	Olberg	Onsala Space Observatory Chalmers University of Technology
Victor	Pankratius	Massachusetts Institute of Technology, USA
Maurizio	Paolillo	Dept. of Physics - University Federico II, Napoli
Jongyeob	Park	Korea Astronomy and Space Science Institute

Reynier	Peletier	University of Groningen, The Netherlands
Maura	Pilia	INAF - OA Cagliari
Kai Lars	Polsterer	Heidelberg Institute for Theoretical Studies, Germany
Troy	Porter	Hansen Experimental Physics Laboratory and Kavli Institute for Particle Astrophysics and Cosmology, Stanford University
Pavlos	Protopapas	Harvard, USA
Nicholas James	Rattenbury	University of Auckland
Giuseppe	Riccio	INAF - Capodimonte Astronomical Observatory
Thomas	Robitaille	CfA - USA
Helge	Rottmann	Max Planck Institute for Radioastronomy of Bonn, Germany
Anna	Scaife	University of Manchester
Nicole	Schanche	University of St Andrews
Bernard	Schutz	Cardiff University, GB
Francesca	Scipioni	USRA - Lunar and Planetary Institute, USA
Kazuhiro	Sekiguchi	National Astronomical Observatory of Japan
Evgeni	Semkov	Institute of Astronomy, Sofia, Bulgaria
Choi	Seonghwan	Korea Astronomy and Space Science Institute
Brigitta	Sipocz	University of Hertfordshire, UK
Petr	Skoda	Astronomical Institute of the Czech Academy of Sciences
Yihan	Song	National Astronomical Observatories, Chinese Academy of Sciences
Peter	Sorensen	NOT - Nordic Optical Telescope, La Palma, Spain
Vladimir	Sreckovic	Institute of Physics, Belgrade
Suzanne	Staggs	Princeton University, USA
Rachel	Street	LCOGT
Anton	Strigachev	Institute of Astronomy, Sofia, Bulgaria
Maria	Süveges	Max-Planck-Institute für Astronomie, Heidelberg, Germany
Brian	Thorsbro	Lund Observatory
Martin	Topinka	Institute for Advanced Studies, Dublin
Alessio	Trois	INAF - OA Cagliari
Diego	Tuccillo	GEPI - Observatoire de Paris; MINES Paris Tech
Mattia	Vaccari	UWC
Edwin A.	Valentijn	Kapteyn Institute, University of Groningen
Thijs (J.M.)	van der Hulst	Kapteyn Astronomical Institute University of Groningen
Iryna	Vavilova	Main Astronomical Observatory of the National Academy of Sciences of Ukraine
Dany	Vohl	Centre for Astrophysics & Supercomputing, Swinburne University of Technology
Veljko	Vujcic	Astronomical Observatory Belgrade
Jiannan	Zhang	National Astronomical Observatories, Chinese Academy of Sciences
Mo	Zhang	National Astronomical Observatories, Chinese Academy of Sciences
Yanxia	Zhang	National Astronomical Observatories, Chinese Academy of Sciences

Olga	Zhelenkova	SAO RAS
Staszek	Zola	Astronomical Observatory, Jagiellonian University
Bingyi	Wang	Beijing Normal University
Mengxin	Wang	National Astronomical Observatories, Chinese Academy of Sciences
Yue	WU	National Astronomical Observatories, Chinese Academy of Sciences
Yaroslav	Yatskiv	Main Astronomical Observatory of NASU
Atsunori	Yonehara	Department of Astrophysics and Atmospheric Sciences, Faculty of Science, Kyoto Sangyo University
Suk-Jin	Yoon	Yonsei University
Hailong	Yuan	National Astronomical Observatories, Chinese Academy of Sciences

5. IAU Grants

IAU has awarded 16.340 euros, which were distributed as it follows:

SURNAME	NAME	GENDER	COUNTRY	status	grant
Bignone	Lucas	male	Argentina	PhD	1500
Mickaelian	Areg	male	Armenia	Senior researcher	800
Vohl	Dany	male	Australia	PhD	690
Gulyiev	Rustam	male	AZERB	PhD	900
Caro	Fernando	male	France	PhD	500
WU	Yue	female	CHINA	young researcher	500
Zhang	Yanxia	female	CHINA	staff researcher	500
Yuan	Hailong	male	CHINA	young researcher	500
Skoda	Petr	male	Czech	Senior researcher	500
Ishida	Emille	female	France	PhD	500
Amaro	Valeria	female	Italy	PhD	600
Riccio	Giuseppe	male	Italy	postdoc	600
Barway	Sudhanshu	male	South Africa	researcher	1000
Blanco-Cuaresma	Sergi	male	SW	postDoc	700
Barrett	Jim	male	UK	PhD	500
Sipocz	Brigitta	female	UK	PhD	900
Botygina	Olga	female	UKR	researcher	650

Fedorova	Elena	female	UKR	postdoc	1000
Kolomiyets	Svitlana	female	UKR	postdoc	1000
Yatskiv	Yaroslav	male	UKR	Prof.	500
Hojaev	Alisher	male	Uzbekistan	Prof.	2000
TOTAL					16340

All the scientists who were awarded the grant came to the meeting, and collected the cash at the moment of registration. All of them signed a receipt which is kept by the Chairman of the SOC G. Longo.