

# ALMARVI

*“Algorithms, Design Methods, and Many-Core Execution Platform for Low-Power Massive Data-Rate Video and Image Processing”*

Project co-funded by the ARTEMIS Joint Undertaking under the

ASP 5: Computing Platforms for Embedded Systems

ARTEMIS JU Grant Agreement no. 621439

## ***D7.7 - Dissemination Report (Final)***

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TUE

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**Description:** This document reports the dissemination activities in the ALMARVI project over M1-M36.  
*(max 5 lines)*

<b>Nature:</b>	O, R		
<b>Dissemination Level:</b>	<b>PU</b>	Public	<b>X</b>
	<b>PP</b>	Restricted to other programme participants (including the JU)	
	<b>RE</b>	Restricted to a group specified by the consortium (including the JU)	
	<b>CO</b>	Confidential, only for members of the consortium (including the JU)	

**DOCUMENT HISTORY**

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**Contents**

**1. Introduction..... 3**

**2. ALMARVI website and content..... 4**

**3. Open software..... 6**

**4. Scientific publications ..... 8**

**5. Participation in public events, tutorials and workshops ..... 15**

**6. Organization of public events, tutorials and workshops..... 17**

**7. Conclusions ..... 20**

**Appendix: conferences and journals..... 21**

# 1. Introduction

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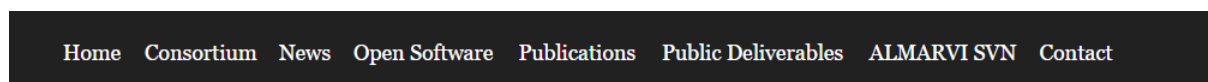
This document describes the dissemination activities performed under the ALMARVI project over the last three years (i.e., M01-M36). As stated in D7.3 (Dissemination strategy and plan), the dissemination activities are performed along three directions:

- Website (Target: the general public, the scientific community, and the industrial community): The ALMARVI website contains and maintains the overview of the project, latest news, publications etc. Further, we equipped the website with **Google analytics** to track the statistical information related to the visibility of ALMARVI project. The Section 2 describes the website and the details of statistical information obtained from the Google analytics over the reporting period.
- Open software (Target: the scientific community and the industrial community): A large number of open software were developed, extended and integrated under the ALMARVI project. The open software are described in the website and the corresponding links to access the software are given. The open software are described in Section 3.
- Scientific publications (Target: the scientific community and the industrial community): A special emphasis is given on project scientific publications in premier conferences and journals with a special focus on embedded systems. The academic partners are more active in national and international scientific publications while the industrial partners are more focused on outreach activities and demonstrations at the national level. Section 4 describes the achievements in terms of scientific publications and outreach over the reporting period.
- Seminars, workshops and tutorials (Target: the industrial community and the scientific community): Along this line, there are two categories of activities. First, as a part of ALMARVI dissemination activities, various partners participated in a number of public events. Section 5 describes the participations in various public events supported by the ALMARVI project in the reporting period. Second, various partners organized a number of public events to further disseminate the ALMARVI results. Section 6 describes the activities in terms of organizing public events in the reporting period.

The D7.6 Dissemination report (intermediate) reported the ALMARVI dissemination activities between M01-M18. This document extends the D7.6 with the dissemination report of the last eighteen months (i.e., M18-M36) of the ALMARVI along the four outlined directions.

## 2. ALMARVI website and content

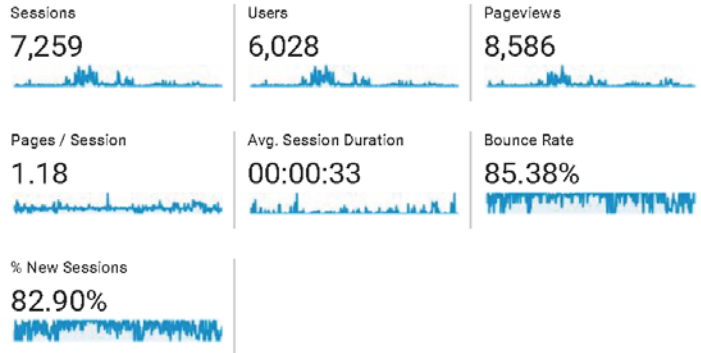
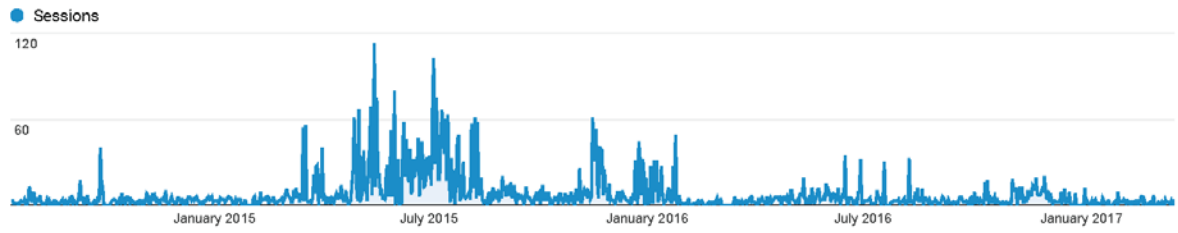
The ALMARVI website ([www.almarvi.eu](http://www.almarvi.eu)) contains overview of the projects, objectives, work packages, details of the consortium, contacts along the latest news and details of the publications. It is maintained and regularly updated with news, publications and public deliverables.



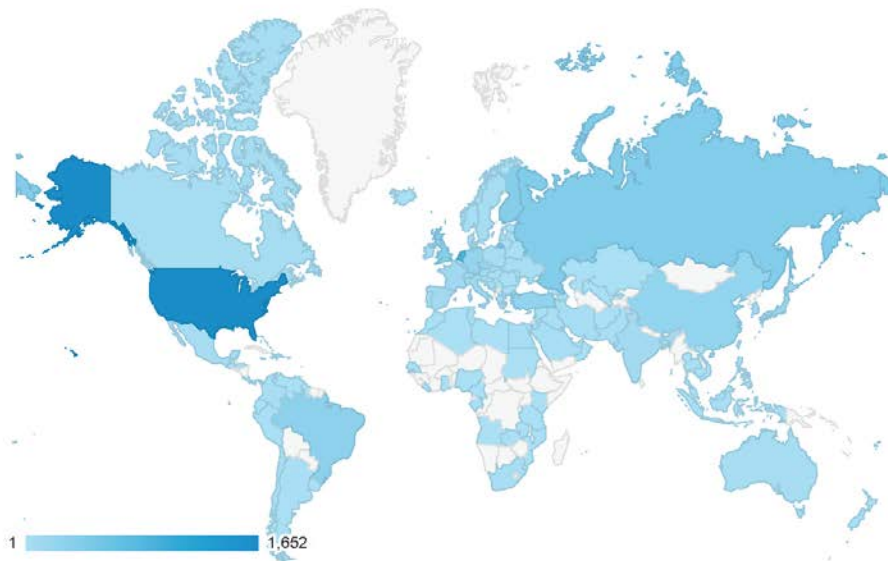
Algorithms, Design Methods, and Many-core Execution Platform for  
Low-Power Massive Data-Rate Video and Image Processing  
Artemis 2013 GA 621439

Project Description	Societal Impact	Objectives
<p><b>Technical Innovation</b></p> <p>Advanced image and video processing systems are becoming a crucial and resource consuming part of embedded applications in many sectors. ALMARVI aims to facilitate the transition from a vertically structured market to a horizontally structured market. In particular, it focuses on reducing overall system design cost and time-to-market and enabling low cost solutions for high volume markets in different industrial domains and creating new market opportunities, and supporting SMEs.</p> <p>The demonstrators developed under this project for the healthcare, security/surveillance/monitoring, and mobile use cases will directly lead to marketable applications and products in their relevant domains. Integrated releases of the image/video processing algorithm libraries, reference design tools and platforms, and system software stack solutions will be made available along with their evaluation for the demonstrated use cases. Cross-domain applicability will reduce fragmentation, thus increasing the market share of European supplier industry.</p>		

**Visibility (using Google Analytics):** Google analytic is used as the ALMARVI web analytic service in order to track and report the website traffic. This deliverable reports the number of views of the website from the time that it has been launched. The statistics are included. The page visits are relatively distributed while countries like the Netherlands has a higher rate of visits. The USA has opened highest number of sessions which indicates a good visibility outside the participating counties. Sessions are also opened from countries like UK, Germany and Brazil. Overall, around 7000 sessions are used by over 6000 users.



Country	Sessions	% Sessions
1.  United States	1,652	22.76%
2. (not set)	1,022	14.08%
3.  Netherlands	804	11.08%
4.  Russia	392	5.40%
5.  Finland	366	5.04%
6.  United Kingdom	329	4.53%
7.  Brazil	273	3.76%
8.  Turkey	233	3.21%
9.  China	229	3.15%
10.  Germany	216	2.98%



## 3. Open software

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The following open software are being in used by various partners in ALMARVI project. These software are linked to ALMARVI website. In the following, we provide a brief description of the software which further helps to understand their importance in ALMARVI.

- **TCE** ([tce.cs.tut.fi](http://tce.cs.tut.fi)): TUT maintains TTA-based Co-Design Environment (TCE) which is a toolset for designing and programming customized processors based on the Transport Triggered Architecture (TTA). The toolset provides a complete retargetable co-design flow from high-level language programs down to synthesizable processor RTL (VHDL and Verilog backends supported) and parallel program binaries. Processor customization points include the register files, function units, supported operations, and the interconnection network.
- **POCL** ([pocl.sourceforge.net](http://pocl.sourceforge.net)): TUT uses Portable Computing Language (pocl) which aims to become a MIT-licensed open source implementation of the OpenCL standard which can be easily adapted for new targets and devices, both for homogeneous CPU and heterogeneous GPUs/accelerators. IT uses Clang as an OpenCL C frontend and LLVM for the kernel compiler implementation, and as a portability layer. Thus, if your desired target has an LLVM backend, it should be able to get OpenCL support easily by using pocl. The goal is to accomplish improved performance portability using a kernel compiler that can generate multi-work-item work-group functions that exploit various types of parallel hardware resources: VLIW, superscalar, SIMD, SIMT, multicore, multithread.
- **rVEX** ([rvex.ewi.tudelft.nl](http://rvex.ewi.tudelft.nl)): TUDelft maintains p-VEX which is an reconfigurable and extensible Very-Long Instruction Word (VLIW) processor. It is part of the overall "Liquid Architectures" research theme within the Computer Engineering Lab at TU Delft, The Netherlands. The p-VEX processor architecture is based on the VEX ISA. The main concept of our design is to be able to dynamically adapt the hardware design to match requirements from the applications and the operating environment. In this manner, resource utilization can be improved for energy savings or increased performance, e.g., by executing additional programs on the "freed" resources. Consequently, our design can be seen as a large wide-issue (up to 8) VLIW processor or as several 2-issue VLIW cores. Our designs have been used also in several courses given at TU Delft and we can make this material available for professors at other institutes upon request.
- **SDF<sup>3</sup>** (<http://www.es.ele.tue.nl/sdf3/>): TUE developed and maintains SDF<sup>3</sup> toolchain. Synchronous dataflow (SDF) is a modelling formalism that allows design-time analysis of multiprocessor applications. SDF<sup>3</sup> is the tool support for SDF based analysis of throughput and latency, and it provides solution to binding and scheduling questions on microprocessors. The recent versions support Cyclo-Static Dataflow (CSDF) and Finite-State-Machine-based Synchronous Dataflow (FSMSADF).
- **TRACE** ([trace.esi.nl](http://trace.esi.nl)): TRACE is a Gantt chart visualization tool capable of presenting (large sets of) activities on resources (and dependencies between them) as a function of the time. Moreover, it allows visualizing multi-dimensional design spaces for easy comparison of design options. Various recent features (e.g., critical path analysis, distance analysis etc.) on TRACE were developed as a part joint activities between TUE and TNO-ESI and are being used in ALMARVI project.
- **SuRmob** ([zoi.utia.cas.cz/mobilesr](http://zoi.utia.cas.cz/mobilesr)): SuRmob is an application for mobile devices (Android) for an acquisition of super-resolved images. Super-resolution is a mathematical algorithm that combines multiple low-resolution input images and creates one image of higher resolution.

We provide an efficient implementation that runs in mobile devices equipped with digital cameras.

- **vfTasks**                    **open-source**                    **parallelization**                    **library:**                    VF maintains <http://sourceforge.net/projects/vftasks/files/vftasks/> -- vfTasks which is a library with a C API containing the following features: - Manage worker thread pools - Inter-thread streaming communication channels - 2-D synchronization for parallelized loops It does not depend on any other libraries other than libc and the pthreads library. The latter can however be easily replaced with custom threading and memory allocation solution, allowing vfTasks to be ported to an embedded CPU or DSP processor. For more information, visit <http://www.vectorfabrics.com/technology/vftasks>. vfTasks is developed by Vector Fabrics (<http://vectorfabrics.com>) and complements Vector Fabrics' Pareon product (<http://vectorfabrics.com/products>) that helps to parallelize a C/C++ application.
- **MAFURES high-level synthesis tool:** MAFURES stands for “Multiplexing Aware FUnction and Register Scheduler”. MAFURES was developed by OZYEGIN with inputs from ASELSAN. Especially due to the pipelined multiplexers of MAFURES, it is able to beat Vivado HLS both in terms of area and clock frequency. MAFURES code can be found at: <https://github.com/nemesyslab/MAFURES>. MAFURES is quite efficient for video processing designs as long as there are no cyclic inter-iteration dependencies.

Apart from the above open software, there are few more relevant software being used by ALMARVI partners, e.g.,

- **OpenCV** - <http://opencv.org/>
- **scikit-learn** - <http://scikit-learn.org>
- **scikit-image** - <http://scikit-image.org/>
- **Python Imaging Library** - <http://www.pythonware.com/products/pil/>

## 4. Scientific publications

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In the following, we report the scientific publications supported by the ALMARVI project so far. A number of technical articles are already published and several dissemination activities are already confirmed (or accepted) at various venues over the last eighteen months. All publications supported by ALMARVI contain the following ALMARVI acknowledgement: "This research is supported by the ARTEMIS joint undertaking under grant agreement no 621439 (ALMARVI)."

### **Scientific publications by various partners in M01-M36:**

1. I. Pöllänen, B. Braithwaite, T. Ikonen, H. Niska, K. Haataja, P. Toivanen, and T. Tolonen, "Computer-Aided Breast Cancer Histopathological Diagnosis – Comparative Analysis of three DTOCS-based Features: SWDTOCS, SW-WDTOCS, and SW-3-4-DTOCS", *4<sup>th</sup> International Conference on Image Processing Theory, Tools, and Applications (IPTA'2014)*, Paris, France, October 14–17, 2014.
2. D. Goswami, D. Müller-Gritschneider, T. Basten, U. Schlichtmann, S. Chakraborty "Fault-tolerant Embedded Control Systems for Unreliable Hardware," International Symposium on Integrated Circuits (ISIC), Singapore, 2014 (December).
3. T. Ikonen, H. Niska, B. Braithwaite, I. Pöllänen, K. Haataja, P. Toivanen, J. Isola, and T. Tolonen, "Computer-Assisted Image Analysis of Histopathological Breast Cancer Images Using Step-DTOCS", *14th International Conference on Hybrid Intelligent Systems (HIS 2014)*, Kuwait, December 14-16, 2014.
4. H. Kultala, T. Viitanen, P. Jääskeläinen, J. Helkala, and J. Takala, "Compiler Optimizations for Code Density of Variable Length Instructions," in Proc. IEEE International Workshop Signal Process. System, Belfast, UK, Oct. 20-22 2014, pp. 127 – 132.
5. T. Viitanen, H. Kultala, P. Jääskeläinen, and J. Takala, "Heuristics for Greedy Transport Triggered Architecture Interconnect Exploration," in Proc. International Conference Compilers Architecture Synthesis Embedded System, New Delhi, India, Oct. 12-17 2014.
6. K. van Gend, Vector Fabrics, "Cut Power Consumption by 5x Without Losing Performance", LinuxCon 2014, Düsseldorf, Germany, Oct. 13-15 2014.
7. Zliobaite, I.; Hollmén, J.; Teittinen, J.; Koskinen L.; "Towards hardware-driven design of low-energy algorithms for data analysis" ACM SIGMOD Record archive, Volume 43 Issue 4, December 2014, Pages 15-20.
8. B. Braithwaite, H. Niska, I. Pöllänen, T. Ikonen, K. Haataja, P. Toivanen, and T. Tolonen, "Optimized Curve Design for Image Analysis Using Localized Geodesic Distance Transformations", *IS&T SPIE Electronic Imaging*, San Francisco, California, USA, February 8–12, 2015.
9. I.Szentandrás, M. Zachariáš, J. Tinka, M. Dubská, J. Sochor, A. Herout, "INCAST", International Symposium on Mixed and Augmented Reality ISMAR 2015, Fukuoka, Japan, October 2015
10. Article in the ARTEMIS-IA news, March 17, 2015: [artemis-ia.eu/news/almarvi.html](http://artemis-ia.eu/news/almarvi.html).
11. Turnquist, M.J.; Hienkari, M. ; Makipaa, J. ; Koskinen, L. ; "A Fully Integrated Self-Oscillating Switched-Capacitor DC-DC Converter for Near-Threshold Loads" IEEE A-SSCC, 2015 (Asian Solid-State Circuits Conference).
12. M. Hradiš, J. Kotera, P. Zemčík and F. Šroubek, "Convolutional Neural Networks for Direct Text Deblurring", Proceedings of The British Machine Vision Association and Society for Pattern Recognition BMVC 2015, Swansea, UK, 2015, pp. 1-13.



13. J. Kotera, B. Zitová and F. Šroubek, "PSF accuracy measure for evaluation of blur estimation algorithms," *2015 IEEE International Conference on Image Processing (ICIP)*, Quebec City, QC, 2015, pp. 2080-2084.
14. A. Brandon, J. Hoozemans, J. Van Straten, A. Lorenzon, A. Sartor, A. Beck, S. Wong, "A sparse VLIW instruction encoding scheme compatible with generic binaries," *2015 International Conference on ReConfigurable Computing and FPGAs (ReConFig)*, Mexico City, 2015, pp. 1-7.
15. J. Hoozemans, J. Johansen, J. V. Straten, A. Brandon and S. Wong, "Multiple contexts in a multi-ported VLIW register file implementation," *2015 International Conference on ReConfigurable Computing and FPGAs (ReConFig)*, Mexico City, 2015, pp. 1-6.
16. Ikonen T., Pöllänen I., Braithwaite B., Haataja K., Toivanen P., Tolonen T., and Isola J.: Morphological Extraction of Cancerous Nucleus in the Diagnostics of Breast Cancer. Intelligent Systems Design and Applications (ISDA'2015), Marrakesh, Morocco, December 14-16, 2015.
17. P. Jääskeläinen, C.S. de La Lama, E. Schnetter, K. Raiskila, J. Takala and H. Berg: "pocl: A Performance-Portable OpenCL Implementation," *Int. J. Parallel Programming*, Vol. 43, Issue 5, pp. 752 – 785, 2015.
18. H. Yviquel, A. Sanchez, P. Jääskeläinen, J. Takala, and M. Raulet, "Embedded Multi-Core Systems Dedicated to Dynamic Dataflow Programs," *J. Signal Processing Systems*, Vol. 80, Issue 1, pp. 121 – 136, 2015.
19. T. Äijö, P. Jääskeläinen, T. Elomaa, H. Kultala, and J. Takala, "Integer Linear Programming Based Scheduling for Transport Triggered Architecture," *ACM Trans. Architecture and Code Optimization*, Vol. 12, Issue 4, pp. 59:1-59:22, 2015.
20. M. Koskela, T. Viitanen, P. Jääskeläinen, J. Takala, and K. Cameron, "Using Half Floating-Point Numbers for Storing Bounding Volume Hierarchies," in *Computer Graphics International Conference*, Strasbourg, France, 2015.
21. V. Korhonen, P. Jääskeläinen, M. Koskela, T. Viitanen, and J. Takala, "Rapid Customization of Image Processors Using Halide," in *Proc. IEEE Global Conf. Signal Inf. Process.*, Orlando, FL, USA, 2015.
22. P. Jääskeläinen, H. Kultala, T. Viitanen, and J. Takala, "Code Density and Energy Efficiency of Exposed Datapath Architectures," *J. Signal Processing Systems*, Vol. 80, Issue 1, pp. 49-64, 2015.
23. J. Glossner, P. Blinzer, and J. Takala, "HSA-Enabled DSPs and Accelerators," in *Proc. IEEE Global Conf. Signal Inf. Process.*, Orlando, FL, USA, 2015.
24. Adyanthaya, S., Alizadeh Ara, H., Bastos, J.P., Baghbanbehrouzian, A., Medina Sanchez, R.A., Pinxten, van, J.H.H., Sanden, van der, L.J., Waqas, U., Basten, A.A., Corporaal, H., Frijns, R.M.W., Geilen, M.C.W., Goswami, D., Stuijk, S., Reniers, M.A. & Voeten, J.P.M. (2015). "xCPS : a tool to eXplore cyber physical systems" *Proceedings of WESE'15 : Workshop on Embedded and Cyber-Physical Systems Education*, October 2015, Amsterdam, The Netherlands.
25. T. Viitanen, M. Koskela, P. Jääskeläinen, H. Kultala, and J. Takala, "MergeTree: A HLBVH Constructor for Mobile Systems," in *ACM SIGGRAPH Asia*, Kobe, Japan, 2015.
26. H. Kultala, J. Multanen, P. Jääskeläinen, and J. Takala, "Impact of Operand Sharing to the Processor Energy Efficiency," in *Proc. CSI Int. Symp. Comput. Arch. & Digital Syst.*, Tehran, Iran, 2015.
27. F. Sroubek, J. Kamenicky, and Y. M. Lu, "Decomposition space-variant blur in image deconvolution," *IEEE Signal Processing Letters*, vol. 23, no. 3, pp. 346-350, 2016.

28. M. Buyukmihci, V.E. Levent, A.E. Guzel, O. Ates, M. Tosun, T. Akgun, C. Erbas, S. Gören, H.F. Ugurdag, "Output Domain Downscaler", in Proc. Intl. Symp. on Computer and Information Sciences (ISCIS), pp. 262-269, Krakow, Poland, Oct 27-28, 2016.
29. A.E. Guzel, V.E. Levent, M. Tosun, M.A. Ozkan, T. Akgun, D. Buyukaydin, C. Erbas, H.F. Ugurdag, "Using High-Level Synthesis for Rapid Design of Video Processing Pipes", in Proc. of East-West Design & Test Symposium (EWDTS), Yerevan, Armenia, Oct 14-17, 2016. DOI: 10.1109/EWDTS.2016.7807644.
30. Hadi Alizadeh Ara, Marc Geilen, Twan Basten, Amir Behrouzian, Martijn Hendriks and Dip Goswami, "Tight Temporal bounds for dataflow applications mapped onto shared resources", Accepted for publication and presentation at the proceeding of the 11th IEEE International Symposium on Industrial Embedded Systems 23-25 May 2016.
31. Amir Behrouzian, Dip Goswami, Marc Geilen, Martijn Hendriks, Hadi Alizadeh Ara, Eelco Horssen, Maurice Heemels and Twan Basten, "Sample-Drop Firmness Analysis of TDMA-Scheduled Control Applications", Accepted for publication and presentation at the proceeding of the 11th IEEE International Symposium on Industrial Embedded Systems 23-25 May 2016.
32. E.P. van Horssen, A.R.B. Behrouzian, D. Goswami, D. Antunes, T. Basten and M. Heemels, "Performance analysis and controller improvement for linear systems with (m,k)-firm data losses", in Proc. European Control Conference, ECC, Aalborg, Denmark, 2016.
33. M. Hendriks, J. Verriet, T. Basten, B. Theelen, M. Brassé, and L. Somers, "Analyzing execution traces — critical-path analysis and distance analysis", Accepted for publication in Springer International Journal on Software Tools for Technology Transfer, 2016.
34. P. Svoboda, M. Hradiš, D. Bařina, and P. Zemčık. Compression Artifacts Removal Using Convolutional Neural Networks. Journal of WSCG. Plzeň: 2016, roč. 24, č. 2, s. 63-72. ISSN 1213-6972.
35. P. Svoboda, M. Hradiš, L. Maršık, and P. Zemčık. CNN for license plate motion deblurring. In: IEEE International Conference on Image Processing (ICIP). Phoenix: IEEE Signal Processing Society, 2016, s. 1-4. ISBN 978-1-4673-9961-6.
36. J. Podivýnský, O. Čekan, J. Lojda, and Z. Kotásek. Functional Verification as a Tool for Monitoring Impact of Faults in SRAM-based FPGAs. In: Proceedings of the 2016 International Conference on Field Programmable Technology. Xi'an: IEEE Computer Society, 2016, pp. 289-290. ISBN 978-1-5090-5602-6.
37. J. Lojda, J. Podivýnský, M. Krčma, and Z. Kotásek. HLS-based Fault Tolerance Approach for SRAM-based FPGAs. In: Proceedings of the 2016 International Conference on Field Programmable Technology. Xi'an: IEEE Computer Society, 2016, s. 297-298. ISBN 978-1-5090-5602-6.
38. Kritchallo V., Braithwaite B., Vermij E., Bertels K., and Al-Ars Z.: Balancing High-Performance Parallelization and Accuracy in Canny Edge Detector. 29th International Conference on Architecture of Computing Systems (ARCS'2016), Nuremberg, Germany, April 4-7, 2016.
39. M. Koskela, T. Viitanen, P. Jääskeläinen, and J. Takala, "Half-Precision Floating-Point Ray Traversal," in Proc. Joint Conf. Comput. Vision Imaging Comput. Graphics Theory Appl., Rome, Italy, 2016.
40. Ikonen Tiia, Haataja Keijo, Toivanen Pekka, Tolonen Teemu, and Isola Jorma: Nuclei Malignancy Analysis Based on an Adaptive Bottom-Hat Filter. Proceedings of the IEEE 16th International Conference on Intelligent Systems Design and Applications (ISDA'2016), Porto, Portugal, December 14-16, 2016.

41. O. Čekan, J. Podivýnský, and Z. Kotásek. Random Stimuli Generation Based on a Stochastic Context-Free Grammar. In: Proceedings of the 2016 International Conference on Field Programmable Technology. Xi'an: IEEE Computer Society, 2016, pp. 291-292. ISBN 978-1-5090-5602-6.
  42. Heikki Kultala, Timo Viitanen, Pekka Jääskeläinen, Jarmo Takala: “Aggressively Bypassing List Scheduler for Transport Triggered architectures.” SAMOS XVI: Embedded Computer Systems: Architectures, MOdeling, and Simulation, Samos, Greece, July 2016.
  43. Joonas Multanen, Timo Viitanen, Pekka Jääskeläinen, Jarmo Takala: “Xor-Masking: a Low-Overhead Method for Instruction Fetch Energy Reduction with Emerging SRAM Technologies.” SiPS 2016: IEEE Workshop on Signal Processing Systems. Dallas, Texas, October 2016.
  44. Joonas Multanen, Heikki Kultala, Matias Koskela, Timo Viitanen, Pekka Jääskeläinen, Jarmo Takala, Karen Egiazarian, Aram Danielyan, Cristóvão Cruz: “OpenCL Programmable Exposed Datapath High Performance Low-Power Computational Imaging Accelerator.” IEEE Nordic Circuits and Systems Conference. Copenhagen, Denmark, November 2016.
  45. N.Behmann, C. Seifert, G. Paya-Vaya, H. Blume, P. Jääskeläinen, J.Multanen, H. Kultala, J. Takala, J. Thiemann, S. van de Par: “Customized High Performance Low Power Processor for Binaural Speaker Localization.” IEEE Int'l Conference on Electronics, Circuits, & Systems. Monte Carlo, Monaco, December 2016.
  46. M. Hendriks, M. Geilen, A.R.B. Behrouzian, T. Basten, H. Alizadeh, and D. Goswami. “Checking metric temporal logic with TRACE,” in 16th International Conference on Application of Concurrency to System Design (ACSD 2016), Torun, Poland, 2016.
  47. Pekka Jääskeläinen, Timo Viitanen, Jarmo Takala, Heiki Berg: “HW/SW Co-design Toolset for Customization of Exposed Datapath Processors”. A book chapter in Computing Platforms for Software-Defined Radio. Springer. December, 2016.
  48. Hadi Alizadeh Ara, Amir Behrouzian, Marc Geilen, Martijn Hendriks, Dip Goswami and Twan Basten, “Analysis and Visualization of Execution Traces of DataFlow Applications”, IDEA Workshop on Integrating Dataflow, Embedded Computing, and Architecture, 2016.
  49. Adyanthaya, S., Alizadeh Ara, H., Nogueira Bastos, J.P., Baghbanbehrouzian, A., Medina Sanchez, R.A., van Pinxten, J.H.H., van der Sanden, L.J., Waqas, U., Basten, A.A., Corporaal, H., Frijns, R.M.W., Geilen, M.C.W., Goswami, D., Hendriks, M., Stuijk, Sander, Reniers, M.A. & Voeten, J.P.M. (2016). “xCPS: a tool to explore cyber physical systems”. ACM SIGBED, 14(1), 81-95.
  50. A. Brandon, J. Hoozemans, J. Van Straten, S. Wong, “Exploring ILP and TLP on a Polymorphic VLIW Processor”, to appear in the proceedings of the 30th International Conference on Architecture of Computing Systems, Vienna, Austria, 2017.
  51. J. Hoozemans, R. Heij, J. Van Straten, S. Wong, “VLIW-based FPGA computational fabric with streaming memory hierarchy for medical imaging applications”, to appear in the proceedings of the 13th International Symposium on Applied Reconfigurable Computing, Delft, the Netherlands, 2017.
- **SAMOS XV, 2015 Special session on “Mid-Term Results of the ALMARVI ARTEMIS project”** organized by J. Takala and Z. Al-Ars includes the following publications:
    - “Multi-Constraint Multi-Processor Resource Allocation” by A. R. B. Behrouzian, D. Goswami, T. Basten, M. Geilen, H. Alizadeh Ara (**TUE**)

- “GPU Implementation of an Anisotropic Huber-L1 Dense Optical Flow Algorithm Using OpenCL” by D. Buyukaydin and T. Akgun (**ASEL**)
  - “Using VLIW Softcore Processors for Image Processing Applications” by J. Hoozemans, S. Wong and Z. Al-Ars (**TUD**)
  - “Power Optimizations for Transport Triggered SIMD Processors” by J. Multanen, T. Viitanen, H. Linjamäki, H. Kultala, P. Jääskeläinen, J. Takala, L. Koskinen, J. Simonsson, H. Berg, K. Raiskila and T. Zetterman (**Multi-partner collaboration: TUT, UTU, NOK**)
  - “Current Analysis Approaches and Performance Needs for Whole Slide Image Processing in Breast Cancer Diagnostics” by I. Pöllänen, B. Braithwaite, K. Haataja, T. Ikonen and P. Toivanen (**UEF**)
  - “Performance evaluation of image noise reduction computing on a mobile platform” by J. Hannuksela, M. Niskanen and M. Turtinen (**VIS**)
  - “Video Chain Demonstrator on Xilinx Kintex7 FPGA with EdkDSP Floating Point Accelerators” by J. Kadlec (**UTIA**)
- **Springer, 2017 Special Issue on ALMARVI results on Springer Journal of Signal Processing Systems organized by Zaid Al-Ars (TUDelft) and Jarmo Takala (TUT)**

The ALMARVI project partners made agreements with the Springer Journal of Signal Processing Systems (JSPS) to publish a special journal issue describing the objectives and achievements of the ALMARVI project. JSPS is an established journal with a field of interest that well covers the objectives of ALMARVI, publishing research on the areas of system design and implementation, algorithms, architectures, and applications. The special issue features 12 scientific papers that provide an overview of the project and highlight how the different partners collaborated to address the various challenges in an integrated way. The special issue will be indexed by many widely used search engines in the field, and will be made publicly accessible. This will keep a permanent record of the achievement of ALMARVI, thereby maximizing the impact of the project and ensuring the visibility of the results to a wider audience.

The structure of the journal special session is as follows:

- Introduction paper discussing the general vision of ALMARVI and the work packages in the project.
- 4 work package papers about the content of the goals and achievements of each work package, e.g.,
- 2 technical papers by a number of collaborating partners from each work package

The submission and publication schedule of the journal is as follows.

Call for papers released: Feb 1, 17

Submission deadline: Apr 1, 17

Feedback and improvements: Jun 1, 17

Final version: Jul 1, 17

Publication: Aug 1, 17

Some of the under preparation submissions for the above special issue are as follows:

- “Modeling and Analysis Techniques On FPGA Accelerator Node Networks for Real-time Streaming Video Processing Applications in the Healthcare Domain” by S.C. van der Vlugt,

- R. J. de Jong, M. Hendriks, H.A. Ara, R. Guerra Marin, M. Geilen, D. Goswami (**PHILIPS, TUE**)
- “ALMARVI demonstrators” by S.C. van der Vlugt and Z. Al-Ars (**All WP5 partners**)
  - “Frame-based programming, stream-based processing” by J. Hoozemans, R. J. de Jong, S.C. van der Vlugt, J. van Straten, Z. Al-Ars (**TUD, PHILIPS**)
  - “Applying Monotonic Optimization to Dataflow Buffer Sizing”, M. Hendriks, H.A. Ara, M. Geilen, T. Basten, R. Guerra Marin, R. J. de Jong, S. C. van der Vlugt (**TUE**)
  - “Board support packages with runtime reconfigurable floating point accelerators for design of video processing algorithms in Xilinx SDSoc environment” by J. Kadlec, Z. Pohl (**UTIA**)
  - “ALMARVI video processing SoC platform on Zynq” by J.J.Hoozemans, T. Viitanen, A. Tervo, J. Kadlec (**UTIA, TUdelft, TUT**)
  - “Image restoration methods: HW platform-related analyzes and optimizations” by J. Kamenicky, F. Sroubek, B Zitova, M. Turtinen, M. Niskanen (**UTIA, VISIDON**)

### **Outreach activities, keynote and presentations by various partners in M01-M36:**

- **Handling blurASELSAN:** ASELSAN intends to present one or two posters/papers in the national conferences and universities in Turkey. Moreover, ASELSAN is planning to participate in a workshop on parallel processing where specific scientific ALMARVI concepts will be presented.
  - **Lead:** Toygar Akgün
  - **NVIDIA GP-GPU meet up in Turkey**
- **Hurja Solutions** aims attend to international fairs when new applications developed in ALMARVI are ready for demonstration. Towards this, it had attended **Slush 2015** which is detailed in Section 4.
  - **Lead:** Antti Väänänen
- **Nokia** aims to participate in a number of international and national fairs and workshops. Along this line, NOK gave a presentation on their results under ALMARVI in a **workshop at WEEE** organized by UTURKU (detailed in Section 5).
  - **Lead:** Heikki Berg
- **CAMEA** aims exhibit with its own booth in a number of national and international trade fairs. Current results of the ALMARVI project such as hardware demos (e.g. object detection in ZYNQ, all-in-one camera solution and so on) were shown in **Expotrafic Moscow 2015, Intertrafic Istanbul 2015, ITS World Congress Bordeaux 2015, Intertrafic Amsterdam 2016** – detailed in Section 4.
  - **Lead:** Lukas Marsik
- **Presentation by Lauri Koskinen (UTURKU)** at **TUE** in May, 2015 on “Adaptive ultra-low power (ULP) processing”. As a part of collaboration under ALMARVI, Lauri Koskinen gave a public presentation and as a followup, possible collaborations are being discussed being these parties.

- **Keynote at IS&T/SPIE Electronic Imaging 2015**, San Francisco, California, United States, February 8 – 12, 2015
  - **Speaker:** Filip Sroubek UTIA (Czech Republic)
  - **Title:** Advances in image restoration: from theory to practice
  
- **Keynote at IDEA Workshop 2016** on Integrating Dataflow, Embedded Computing, and Architecture
  - **Speaker:** Zaid Al-Ars, TUDelft (Netherlands)
  - **Title:** High Performance Embedded Computing Using Heterogeneous Computational Fabrics - The ALMARVI Vision and Beyond
  
- **Invited talk by Fatih Ugurdag (OZyegin)** at **IEEE EAST-WEST DESIGN & TEST SYMPOSIUM** in September, 2015.

## 5. Participation in public events, tutorials and workshops

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In the following, we summarize the participation in public events, tutorials and workshops by the ALMARVI partners in the reporting period.

- **Participation and presentation Artemis/ECSEL Brokerage 2015 Event by UEF**, Amsterdam, Netherlands by Pekka Toivanen and Keijo Haataja.
- **Participation in Slush 2015 event in Helsinki:** Hurja Solutions attended to look for new business opportunities for services and applications which are developed in ALMARVI project.
- **Participation in ICTexpo 2016 event in Helsinki:** Hurja Solutions attended to look new business opportunities for services and applications which are developed in ALMARVI project.
- **Participation in Expotrafic 2015 in Moscow:** Tomas Bia (collaborator of CAMEA) attended a number of talks and had fruitful discussions regarding technology addressed in ALMARVI project. The audience was various industrial bodies and customers.
- **Participation in Artemis - ITEA II Co-summit** in March, 2015 by UTIA and UEF at Berlin Congress Center, Germany, ALMARVI booth
  - Lead: Jiri Kadlec, Pekka Toivanen, Keijo Haataja, Lauri Väättäinen, and Maarit Tamminen
- **Participation in Intertraffic in Istanbul 2015 by CAMEA:** Poster presenting intermediate results of ALMARVI project by Lukas Marsik and Tomas Bia. The audience was various industrial bodies and customers.
- **Participation in Intelligent Traffic Systems (ITS) 2016 World Congress Bordeaux by CAMEA by CAMEA:** Poster presenting intermediate results of ALMARVI project by Lukas Marsik and Lucie Brnkova. The intermediate prototype of the Zynq-based detector has been shown as well. The audience was various industrial bodies and customers.
- **Participation in Intertraffic Amsterdam 2016 by CAMEA:** Poster presenting pre-final results of ALMARVI project by Lukas Marsik and Lucie Brnkova. The pre-final prototype of the Zynq-based all-in-one camera with object detector has been shown as well. The audience was various industrial bodies and customers.
- **Participation in TNO-ESI Symposium, Eindhoven, April 2016 by TU Delft** (Joost Hoozemans and Zaid Al-Ars): Demo on real-time schedulability
- **Participation in Artemis/ECSEL Brokerage 2016 Event in Strasbourg, France by UEF**, by Keijo Haataja.
- **Participation in HiPEAC, Stockholm, January 2017 by TU Delft** (Joost Hoozemans):
  - Presentation at Workshop Reconfigurable Computing: “Improved dynamic cache sharing for communicating threads on a runtime-adaptable processor” (no formal proceedings)
  - Poster: „Liquid Architectures - The p-VEX Polymorphic VLIW Processor”
- **Participation in Digital Innovation Forum (DIF) 2017 in Amsterdam by ARTEMIS-IA and ITEA:** Presentation of Almarvi results at booth with demos from several partners
  - PHILIPS, UTIA, TUD
- **Participation in Artemis/ECSEL Brokerage 2017 Event in Brussels, Belgium by UEF**, by Keijo Haataja.
- **Participation and presentation in 2<sup>nd</sup> Tensilica Day, 2017, Hanover, Germany** by Pekka Jääskeläinen (TUT). Presented the TCE toolset further developed in the ALMARVI project.

- **Participation and presentation in Workshop on System-Level Design for Signal and Information Processing”, Oct. 24, 2016 in College Park, MD, US by Jarmo Takala / TUT.** Presented the TCE toolset further developed in the ALMARVI project.
- **Participation in ICT.OPEN 2017 in Amersfoort, NL by TU Delft (Joost Hoozemans, Jeroen van Straten)**
  - Presentation (full length oral presentation and poster) at PROGRESS track: ‘VLIW-based FPGA Computation Fabric with Streaming Memory Hierarchy for Medical Imaging Applications’
  - Demo of both the 64-core streaming platform and the dynamic core, awarded with the **best Demo award** (Meet the Demo Award 2017)



## 6. Organization of public events, tutorials and workshops

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In the following, we report the dissemination by organizing in public events, tutorials and workshops in the ALMARVI partners.

- **Special session in SAMOS 2015 on ALMARVI**

**Session Organizers:** Zaid Al-Ars (TUDelft, Netherlands), Jarmo Takala (TUT, Finland)

**Description:** The expected participants include international technology experts, healthcare and security industry representatives, image processing device manufacturers, end users, industry and research representatives as well as the project partners. All partners will be invited to submit their contributions. The special session will have about 6 papers, preferably about collaborative work between different partners.

- **ALMARVI Workshop at Ozyegin University** in 2015 in Istanbul, Turkey

**Organizer:** OZYEGIN (Fatih Ugurdag) and Aselsan (Toygar Akgün)

**Description:** Application of ALMARVI results in parallel processing, and effective GPU programming and its application to video processing with target audience university researchers, doctoral candidates and graduate/undergraduate students

- **Organizing Workshop at WEEE by UTURKU:** 3rd Workshop on Energy Efficient Electronics and Applications in 10-12 September 2015, Helsinki, Finland.

**Organizer:** Lauri Koskinen (UTURKU)

**Description:** The objective of the workshop is to bring together experts, from both industry and academia, to discuss the challenges and the latest trends in the development of low-power and ultra-low-power embedded systems. In addition to the workshop, an optional student day will be organized in September 10th. The day includes two separate courses on high-level processor design: Designing TTA processors with TCE ([tce.cs.tut.fi](http://tce.cs.tut.fi)) and Constructing Hardware in a Scala Embedded Language (<https://chisel.eecs.berkeley.edu/>).

- 10<sup>th</sup> September (student day): Course on TTA architectures

- 11<sup>th</sup> September (Workshop day 1: 2 ALMARVI related presentation (Nokia, TUT)

- 12<sup>th</sup> September (Workshop day 2): ALMARVI related presentation (Phillips Healthcare)

- **Tutorial in ESWEEK in October, 2015 in the Netherlands** by TUE and TUDelft (and TNO). The tutorial and the presented work is supported by ARTEMIS projects **621429 EMC2** and **621439 ALMARVI**

**Organizer:** Dip Goswami (TUE)

**Speakers:** Teun Hendriks (TNO), Zaid Al-Ars (TUDelft) and Dip Goswami (TUE)

**Title:** “Design Challenges in Compute-intensive Mixed-criticality Systems: System, Platform and Application Perspectives”

**Description:** This tutorial is composed of three parts: System perspective (Part 1), Platform perspective (Part 2) and Application perspective (Part 3). At the system-level, architectural design and deployment challenges will be illustrated based on an industrial use-case stemming from the collaboration between TNO ([www.TNO.nl](http://www.TNO.nl)) and NXP ([www.nxp.com](http://www.nxp.com)), and extended with results of TNO’s research in the European Artemis project EMC2 ([artemis-emc2.eu](http://artemis-emc2.eu), grant no. 621429). Next, at the platform-level, the tutorial will draw its motivation

from the healthcare domain, iXR in particular, and illustrate results from the ongoing European Artemis project ALMARVI ([almarvi.eu](http://almarvi.eu), grant no. 621439). Finally, at the application-level, the tutorial will discuss various performance and trade-offs analysis methods for embedded control systems while considering shared implementation platforms. Results will be shown from the ongoing activities under both the EMC2 and ALMARVI projects.

**Details:** <http://www.es.ele.tue.nl/~dgoswami/ESWeek2015Tutorial.pdf>

- **Seminar Series at OZYEGIN University, Istanbul, Turkey, August, 2016**
  - **Speaker:** Aydin E. Guzel
  - **Title:** MAFURES
  
- **Presentation at International Symposium on Computer and Information Sciences (ISCIS), Krakow, Poland, October 2016**
  - **Speaker:** V. Emre Levent
  - **Title:** Output Domain Downscaler
  
- **Presentation at IEEE East-West Design & Test Symposium (EWDTS), Yerevan, Armenia, October 2016**
  - **Speaker:** Aydin E. Guzel
  - **Title:** Using High-Level Synthesis for Rapid Design of Video Processing Pipes
  
- **Tutorial at ICPR\_23rd International Conference on Pattern Recognition, Cancun, Mexico, December, 2016**
  - **Speaker:** Filip Sroubek, Barbara Zitova, Jan Flusser
  - **Title:** Handling Blur
  
- **IDEA Workshop 2016 on Integrating Dataflow, Embedded Computing, and Architecture** organized by **Twan Basten (TUE), Waheed Ahmad, and Alok Lele. Proceedings are available as:** Waheed Ahmad, Twan Basten, Robert de Groote, Alok Lele, and Orlando Moreira (eds.), IDEA 2016: Integrating Dataflow, Embedded Computing, and Architecture, Proceedings. Report ESR-2017-01, Eindhoven University of Technology, Department of Electrical Engineering, Eindhoven, the Netherlands, January 2017.
  - **Keynote by Zaid Al-Ars (TU Delft):** High Performance Embedded Computing Using Heterogeneous Computational Fabrics - The ALMARVI Vision and Beyond
  - The workshop accepted 11 extended abstracts and full papers for interactive and full presentations, including the following from TUE –
    - “Analysis and Visualization of Execution Traces of DataFlow Applications” by Hadi Alizadeh Ara, Amir Behrouzian, Marc Geilen, Martijn Hendriks, Dip Goswami and Twan Basten
  - Extended abstracts of all presented submissions have been published in the above mentioned proceedings. Selected full papers from the workshop have been published in a special section of ACM Transactions on Design Automation of Electronic Systems (TODAES) after an open call for papers and four review rounds – publication details are given below

- **Special Section: Integrating Dataflow, Embedded Computing and Architecture** by **Twan Basten (TUE)**, Orlando Moreira, Robert de Groote. Editorial, ACM Transactions on Design Automation of Electronic Systems (TODAES), 22(2), Article No. 35, February 2017, <http://doi.org/10.1145/3023455>
- **Tutorial in ARC by TU Delft** (13<sup>th</sup> International Symposium on Applied Reconfigurable Computing), Delft, The Netherlands, April 3 - 7, 2017  
**Organizer:** Joost Hoozemans, Jeroen van Straten, Stephan Wong (TU Delft)  
**Description:** On the last day of ARC, a tutorial is organized to familiarize the participants with the  $\rho$ -VEX platform that is developed at Delft University of Technology. The tutorial will highlight 2 use cases of the platform; 1) The FPGA prototype of the dynamic core, 2) An FPGA overlay fabric consisting of 64 cores running on 200MHz targeting streaming image processing workloads. There will also be room for participants to port their application of interest to one (or both) the platforms to experiment with either the reconfigurable properties or the streaming fabric under guidance of the  $\rho$ -VEX developers.  
**Details:** <http://www.arc2017.tudelft.nl/program/#workshopfriday>

## 7. Conclusions

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This document has described the dissemination activities under ALMARVI project over its lifetime. ALMARVI partners have shown their visibility in various national and international forums reaching all three categories of targets – the general public, the scientific community and the industrial community. The Google analytics shows the international visibility of the ALMARVI activities. Summary is the following:

- Nearly 50 high quality scientific articles are published in well-known conferences and journals.
- The ALMARVI partners organized 8 workshops and conference special sessions in renowned conferences. There are 2 journal special issues (i.e., TODAES and Springer JSP) either published or planned to be published on ALMARVI related activities. Further, Springer JSP is going to publish ALMARVI results of all the work packages.
- Around 10 keynote speeches, tutorials and invited talks are given by different ALMARVI partners.
- ALMARVI supported development of 8 open software and all of them linked to ALMARVI website.

Finally, the ongoing activities on demonstrators will be further disseminated in the form of various publications. Moreover, the university partners (e.g., TUE, TUD, TUT, BUT, OZYEGIN) are going to produce a number of doctoral theses from the works by the PhD candidates under ALMARVI. It is expected to publish around 5 doctoral theses. For example, two PhD candidates supported by ALMARVI at TUE are expected to graduate in 2018.

## Appendix: conferences and journals

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1. DATE: Design, Automation & Test in Europe
2. DAC: Design Automation Conference
3. EMSOFT: International Conference on Embedded Software
4. RTAS: Real-Time and embedded technology and Applications Symposium
5. IEEE CCV: IEEE Conference on Computer Vision
6. CASES: International Conference on Architectures, Compilers and Synthesis of Embedded Systems
7. IEEE ICASSP: IEEE International Conference on Acoustics, Speech, and Signal Processing
8. ISSCC: International Solid-state Circuit Conference
9. ICIP: International Conference on Image Processing
10. CAIP: International Conference on Computer Analysis of Images and Patterns
11. WSCG: International Conferences in Central Europe on Conference on Computer Graphics, Visualization and Computer Vision
12. IPTA: Inverse Problem – from Theory to Application
13. HIS: Healthcare Infection Society
14. SAMOS: International Conference on Embedded Computer Systems: Architecture, Modeling and Simulations
15. ARITH: IEEE Symposium on Computer Arithmetic
16. FPGA: International Symposium on Field-Programmable Gate Arrays
17. VISAPP: The International Conference on Computer Vision Theory and Applications
18. ACIVS: Advanced Concepts for Intelligent Vision systems
19. ICPR: IEEE International Conference on Pattern Recognition
20. BMVC: British Machine Vision Conference
21. FPL: The International Conference on Field Programmable Logic and Applications
22. SCCG: Spring conference on Computer Graphics
23. ARC: International Symposium on Applied Reconfigurable Computing
24. DIF: Digital Innovation Forum
  
25. IEEE TPAMI: IEEE Transactions on Pattern Analysis and Machine Intelligence
26. IEEE TC: IEEE Transactions on Computers
27. IEEEETCST: IEEE Transactions on Control Systems Technology
28. IEEE TCAS: IEEE Transactions on Circuits and Systems
29. IEEE TVLSI: IEEE Transactions on Very Large Scale Integration (VLSI) Systems
30. IEEE TIP: IEEE Transactions on Image Processing
31. ACM TODAES: Transactions on Design Automation of Embedded Systems
32. ACM TECS: ACM Transactions on Embedded Computing Systems
33. JSA: Journal of Systems Architecture
34. JRTIP: Journal of Real-Time Image Processing