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IZVEŠTAJ

REPORT

# AKTIVNOSTI GRUPE ZA DIGITALNU OBRADU SLIKE, TELEMEDICINU I MULTIMEDIJU (IPTM), SA ELEKTROTEHNIČKOG FAKULTETA UNIVERZITETA U BEOGRADU, U PROJEKTIMA IZ TELEMEDICINE

# ACTIVITIES OF THE GROUP FOR DIGITAL IMAGE PROCESSING, TELEMEDICINE AND MULTIMEDIA (IPTM), FROM THE FACULTY OF ELECTRICAL ENGINEERING, UNIVERSITY OF BELGRADE, IN TELEMEDICINE PROJECTS

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Grupa za Digitalnu obradu slike, telemedicinu i Multimediju (IPTM) je osnovana 1995. godina na Elektrotehničkom fakultetu (ETF) Univerziteta u Beogradu, http://iptm.etf.rs, sl. 1. Od samog početka grupa IPTM je bila intenzivno uključena u različite naučne i istraživačke projekte. Pored ostalog, veoma čvrsta saradnja je ostvarena sa Institutom za patologiju i sudsku medicinu, koji je vodio prof. Petar Spasić, sa Vojnomedicinske akademije (VMA) u Beogradu. Profesor Spasić, sa saradnicima, pre svega, Mr Ivicom Milosavljevićem, je oformio Telemedicinski centar na VMA i prvu telemedicinsku mrežu u Srbiji (godine 1997) [1-3], koja je još uvek u neprekidnom radu [4]. Aktivnosti VMA i ETF-a u polju telemedicine su prepoznate u drugim medicinskim i istraživačkim centrima u Evropi, i više naučnih skupova u Srbiji je posvećeno ovoj oblasti. Više detalja o tome čitalac može naći na sajtu http://www.telemed.co.yu/. Pored ostalog, Akademija medicinskih nauka Srpskog lekarskog društva, u saradnji sa VMA, je bila organizator medjunarodnog naučnog skupa, 2000. godine, kada je štampana i dvojezična (srpsko-engleska) monografija *Telemedicina* [5], a 7-mi međunarodni naučni skup poznat kao *Akademija Studenica*, www.onk.ns.ac.yu/letopis/LSAindex.htm, bio je posvećen upravo Telemedicini, 2001. godine. Brojni vrhunski stručnjaci su prisustvovali ovom skupu, pored ostalih, Klaus Kayser (Nemačka), Vincenzo Della Mea (Italija), Janina Slodkowska (Poljska). Grupa IPTM je uključena u internacionalne projekte [6,7], i više nacionalnih projekata vezanih za telemedicinu i obradu medicinskih slika [8–11], sl. 2. Pri analiziranju medicinskih signala i slika, osim standard-

The Digital Image Processing, Telemedicine, and Multimedia (IPTM) Group was established in 1995, within the Faculty of Electrical Engineering (ETF), University of Belgrade, http://iptm.etf.rs, Fig. 1. From the very beginning, the IPTM Group has been hardly involved in different scientific and research projects. Among others, very strong connections have been realized with the Institute of Pathology and Forensic Medicine, leaded by Prof. Petar Spasić, at the Military Medical Academy (MMA) in Belgrade, Serbia. Professor Spasić, with his associates, mainly with MSc Ivica Milosavljević, MD, established the Telemedicine Center in MMA and the first telemedicine network in Serbia (in 1997) [1-3], which is still in permanent work [4]. The activities in the field of Telemedicine in MMA and ETF in Belgrade were recognized in other medical and research centers in Europe, and several scientific events in Serbia were devoted to this field. More details reader may find in the web site www.telemed.co.yu/. Among others, the Academy of Medical Sciences of Serbian Medical Association, in cooperation with the MMA, has been the organizer of the international meeting in 2000, when the bilingual (Serbian-English) textbook *Telemedicine* was printed [5], and the 7$^{th}$ international scientific meeting known as the *Academy of Studenica*, www.onk.ns.ac.yu/letopis/LSAindex.htm, has been devoted just to Telemedicine, in 2001. The number of top-level scientists participated this event, for instance, Klaus Kayser (Germany), Vincenzo Della Mea (Italy), Janina Slodkowska (Poland). The IPTM Group was involved in international projects [6,7], and in several national projects connected to Telemedi-

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nih metoda obrade, koristili smo i nelinearne obrade, na primer, multifraktalnu analizu [12–15].

Veoma veliki napori članova grupe IPTM su bili usmereni ka evropskom projektu COST 292, u oblasti multimedije [16], što je dovelo do publikovanja velikog broja radova, npr., [17–24].

Najnoviji projekat u koji je intenzivno uključena IPTM grupa je evropski COST projekat IC0604, „Anatomic Telepathology Network (EURO-TELEPATH)“ [25], sl. 3. Cilj tog projekta je koordinacija istraživačkih napora za razvoj najpogodnijeg tehnološkog sistema za upravljanjem multimedijalnih elektronskih zdravstvenih podataka (signali i slike) putem Interneta. Projekat će kombinovati najnovije istraživačke rezultate u području informatike, primenjene na anatomsku patologiju, u cilju eventualnog razvoja i povezivanja, uz podršku nacionalnih i drugih evropskih programa, standarda za prikazivanje, interpretaciju, pretraživanje i pronalaženje digitalnih medicinskih slika uz zadržavanje njihovog dijagnostičkog kvaliteta, što je neophodno za kliničku, edukativnu i istraživačku primenu. U narednom koraku, ovo koordinisano istraživanje bi trebalo da obezbedi kompletan istraživačko-razvojni projekat kojim će se realizovati veoma potrebna pretraživačka alatka (mašina) bazirana na web servisima. To će, definitivno, otvoriti put za integraciju, pretraživanje, pristup, razmenu i dopunjavanje digitalnih patoloških snimaka i pridruženih izveštaja među različitim bolničkim informacionim sistemima, nezavisno od njihove lokacije.

Kao i u ostalim COST projektima, Upravni odbor (MC = *Management Committee*) koordinira projektom, dok se tehničke aktivnosti odvijaju u okviru radnih grupa (WG). Formirane su četiri radne grupe: WG1 – *Modelovanje poslova oko patologije*, WG2 – *Informatički standardi u pathologiji*, WG3 – *Slike: Analiza, obrada, pronalaženje i rukovanje*, i WG4 – *Tehnologije i automatizacija u patologiji*. Akcijiom rukovodi prof. Marcial Garcia Rojo, iz Španije (Opšta bolnica u Ciudad Real, kod Madrida). Do danas je 16 zemalja Evrope, zajedno sa Srbijom, pristupilo ovom projektu.

Nakon osnivačkog sastanka projekta IC0604, u Briselu, 6. novembra 2007., do danas, održano je pet dodatnih susreta: u Madridu (Španija) 1–2 februara 2008 (Upravni odbor i sve radne grupe, RG); u Berlinu (Nemačka) 8–9 maja 2008 (RG1); u Toledu (Španija) 15–17 maja 2008 (RG2); u Evori (Portugalija) 2–3 oktobra 2008 (Upravni odbor i sve RG), sl. 4–6; i u Varšavi (Poljska) 28–29 novembra 2008 (RG3 i RG4), kada se održao i skup "Quantitative Immuno-histochemistry in Digital Pathology", sl. 7. Na tom skupu, koji je organizovala prof. Janina Slodkowska, prikazano je 15 radova kroz četiri sednice. Deo aktivnosti grupe IPTM je prikazan kroz jedan rad [26], koji je opisao originalno razvijen računarski alat

cine and Medical Image Processing [8-11], Fig. 2. When analyzing medical signals and images, except standard processing methods, we applied also nonlinear methods, for instance, the multifractal analysis [12-15].

Very strong efforts of the IPTM Group members were addressed to an EU project COST Action 292, in the field of multimedia [16], leading to a number of published papers, for instance, [17-24].

The newest project, where the IPTM Group is hardly involved, is an EU project COST Action IC0604, "Anatomic Telepathology Network (EURO-TELEPATH)" [25], Fig. 3. The objective of this Action is the coordination of research efforts to develop the most adequate technological framework for the management of multimedia electronic healthcare records (data and images) through the Internet. The Action will consolidate the most renowned research references in the field of informatics applied to Anatomic Pathology in order to eventually develop, with support of national and other European programs, the fusion standards to represent, interpret, browse and retrieve digital medical images while preserving their diagnostic quality as needed for clinical, learning and research purposes. In a latter stage, this coordinated research shall bring about a comprehensive R&D project which will deliver a much needed world wide search engine based on WebServices. This will definitively open the path to integration, search, access, exchange and upgrade of digital pathological images and associated reports among different hospital information systems regardless of their location.

As in other COCT projects, the Management Committee (MC) coordinates the whole Action, while technical activities will be performed through working groups (WGs). The four WGs are consolidated: WG1 – *Pathology Business Modelling*, WG2 – *Informatics Standards in Pathology*, WG3 – *Images: Analysis, Processing, Retrieval and Management*, and WG4 – *Technology and Automation in Pathology*. The Action Chair is Prof. Marcial Garcia Rojo, from Spain (Hospital Ciudad Real, near Madrid). Up to now 16 countries from the Europe, including Serbia, participated in this Action.

From the kick-off meeting of the Action IC0604, in Brussels, on November 6, 2007, up to now five additional meetings were held: in Madrid, Spain, Feb. 1-2, 2008 (MC and all WGs); in Berlin, Germany, May 8-9, 2008 (WG1); in Toledo, Spain, May 15-17, 2008 (WG2); in Evora, Portugal, Oct. 2-3, 2008 (MC and all WGs), Figs 4-6; and in Warsaw, Poland, Nov. 28-29, 2008 (WG3 and WG4), when the Workshop on "Quantitative Immuno-histochemistry in Digital Pathology" was held as well, Fig. 7. In this workshop, organized by Prof. Janina Slodkowska, 15 papers were presented through four sessions. A part of the activities of the IPTM Group was represented by one paper

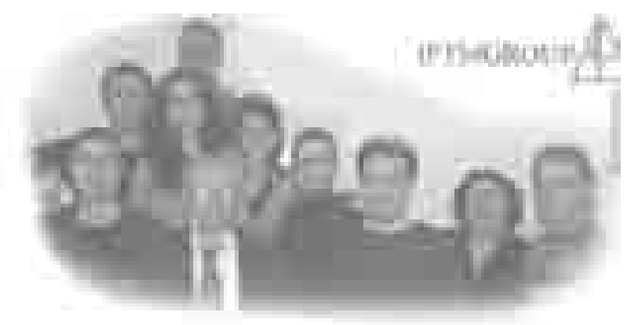
za detekciju mikrokalcifikacija u digitalozovanim mamogramima. Primetimo da su dva bivša saradnika prof. Spasića takodje prikazala rad [27] koji je opisao njihova istraživanja zajedno sa prof. Klausom Kayserom. Svi radovi sa ovog skupa biće štampani u poljskom časopisu *Folia Histochemica et Cytobiologica*, u Februaru 2009 (očekivano vreme).

Na osnovu zajedničkih standarda razvijenih od Evropske komisije za standardizaciju (CEN), konzorcijuma za globalnu mrežu (WC3) i drugih tela (DICOM, HL7, SNOMED, JPEG), direktni rezultati ovog projekta treba da dovedu do novog tehničkog okvira za patologiju (IHE Pathology = *Integrating the Healthhcare Enterprise*), što bi dovelo do novog referentnog standarda za specijalizovanu industriju elektronskog zdravlja kao i kompletnog medicinskog društva. Očekuje se da će mnogi rezultati iz projekta COST 292 (na primer, pretraživanje slika i kompresije) naći primenu u novoj akciji IC0604. Prethodni rezultati grupe IPTM ulivaju nam realan optimizam u pogledu značaja naše grupe u ovom projektu, i očekujemo da ćemo biti ravnopravan partner u narednim aktivnostima upravljanja projektom i istraživačkim aktivnostima.

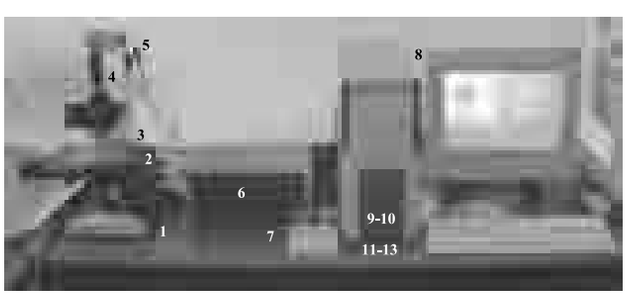
[26] describing originally developed computer tool for detection of microcalcifications in digitized or digital mammograms. Note that two former assistants of Prof. Spasić presented the paper [27] describing their recent work with Prof. Klaus Kayser. All papers from this Workshop will be printed in the Polish journal *Folia Histochemica et Cytobiologica*, in February 2009 (expected).

Based on common standards developed by European Normalization Committee (CEN), the World Wide Web Consortium (W3C) and other bodies (DICOM, HL7, SNOMED, JPEG), the direct result of this Action shall be a new Pathology Technical Framework (IHE Pathology = *Integrating the Healthhcare Enterprise*) to be taken as a new reference standard by the specialized E-health industry as well as the entire medical community. Many results from COST 292 Action (image retrieval and image compression, for instance) can take a place in the new IC0604 Action. The previous results of the IPTM Group give us the realistic optimism concerning the role of our group in this Action, and we expect to be an equal valued partner in further management and research activities.

## SLIKE



*Slika 1 – Deo grupe IPTM sa Elektrotehničkog fakulteta, Univerziteta u Beogradu*
*Figure 1 – Part of the IPTM Group from the Faculty of Electrical Engineering, University of Belgrade*

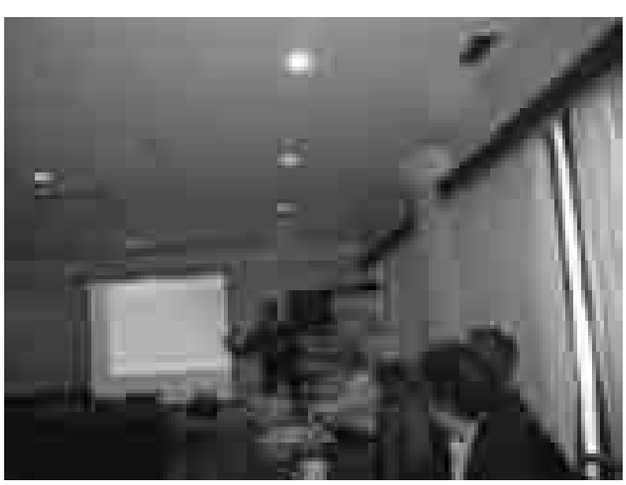



*Slika 2 – ADM sistem (automatizovan digitalizovan mikroskop), realizovan u IPTM laboratoriji.*
*Figure 2 – ADM system (Automated Digitized Microscope), realized in the IPTM Laboratory.*


*Slika 3 – Zvanični poster COST projekta IC0604.*
*Figure 3 – Official poster of the COST Action IC0604.*

*Slika 4 – Centralni trg u Evori, Portugalija, 3. oktobar, 2008.*
*Figure 4 – Central square in Evora, Portugal, October 3, 2008.*

*Slika 6 – Sa sastanka radne grupe 3 u Evori, Portugalija.*
*Figure 6 – During the WG3 meeting in Evora, Portugal.*



*Slika – 5 Profesor Marcial Garcia Rojo na MC sastanku u Evori.*
*Figure – 5 Prof. Marcial Garcia Rojo during MC meeting in Evora.*

*Slika 7 – Zvanični plakat skupa u Varšavi, 29. novembar 2008.*
*Figure – 7 Official poster of the Workshop in Warsaw, Nov. 29, 2008.*

## REFERENCES:


1. I. Milosavljević, P. Spasić, D. Mihajlović, M. Kostov, S. Mihajlović, R. Marković, S. Ristić, „Telepathology – Second opinion network in Yugoslavia", *Advances in Clinical Pathology*, Vol. 2, No. 2, p. 156, April 1998.
2. P. Spasić, B. Reljin, I. Milosavljević, S. Mijušković, S. Ristić, R. Marković, P. Kostić, I. Rakočević, D. Mijatović, „Telemedicine: First telepathology network in Yugoslavia" (invited paper), in *Proc. 6th TELFOR*, pp. 561–568, Belgrade (Yugoslavia), Nov. 1998.
3. B. Reljin, P. Kostic, I. Milosavljevic, P. Bakic, A. Maidment, „A comparison of design and implementation issues in Yugoslav and US PACS," *Radiology*, Vol. 225(P), p. 692, 2002.
4. B. Reljin, P. Spasić, I. Milosavljević, P. Kostić, S. Mijušković, "10+ years experiences of telemicroscopy in Serbia", in *Proc. Conf. Fundamental Space Research*, pp. 01–04, Sunny Beach, Bulgaria, 21–28 Sep 2008.
5. P. Spasić, I. Milosavljević, M. Jančić-Zguricas (Editors), *Telemedicine*, Academy of Medical Sciences of Serbian Medical Association, Belgrade, 2000.
6. „TELEMEDICINE - ATM transfer with small cell loss rate", Bilateral Project SRJ-Italy, Theme 9, 1997–1999.
7. „REMOPAT: Remote monitoring of patients", Joint Yugoslav-Greece Project, 2001–2004.
8. „Objective diagnostic method of determining HER2 rate in oncology, by using digital processing of microscopy images", Project no. 2105 from Basic Research in Medicine, funded by Serbian Ministry of Science, 2002–2005.
9. „Estimation of the influence of drugs on the regulatory mechanisms in cardiovascular systems, by using computer-aided methodologies: spectral and multifractal analyses of cardiovascular signals", Project no. 1774 from Basic Research in Medicine, funded by Serbian Ministry of Science, 2002–2004.
10. „Automated detection of microcalcifications in digitized mammograms targeted to an early detection of a breast cancer", Project no. 145096 from Basic Research in Medicine, funded by Serbian Ministry of Science, 2006–2010.
11. „System for remote control of automated digitized microscope (ADM) for telemedicine applications", Innovative Project no. 451–01–02960/206–94, funded by Serbian Ministry of Science, 2007–2008.
12. I. Reljin, B. Reljin, „Fractal geometry and multifractals in analyzing and processing medical data and images", *Archive of Oncology*, Vol. 10, No. 4, pp. 283–293, 2002.
13. M. Avramov Ivic, S. D. Petrovic, E. Kalman, T. Milosavljevic, I. Reljin, B. Reljin, G. Bogdanovic, V. Vit. Baltic, and Z. Keresztes, „AFM studies of DNA structures extracted from adriamycin treated and non-treated Erlich tumor cells", *Journal of the Serbian Chemical Society*, Vol. 70, Issue 6, pp. 823–831, 2005.
14. T. Stojic, I. Reljin, B. Reljin, „Adaptation of multifractal analysis to segmentation of microcalcifications in digital mammograms", *Physica A: Statistical Mechanics and its Applications*, Elsevier, Vol. 367, pp. 494–508, 2006.
15. I. Reljin, B. Reljin, M. Avramov-Ivic, D. Jovanovic, G. Plavec, S. Petrovic, G. Bogdanovic, „Multifractal analysis of the UV/VIS spectra of malignant ascites: Confirmation of the diagnostic validity of a clinically evaluated spectral analysis", *Physica A: Statistical Mechanics and its Applications*, Vol. 387, Issue 14, pp. 3563–3573, 1 June 2008
16. COST Action 292, „Semantic multimodal analysis of digital media", http://www.cost292.org/, 2004–2008.
17. S. Čabarkapa, N. Kojić, V. Radosavljević, G. Zajić, B. Reljin, „Adaptive content-based image retrieval with relevance feedback", in *Proc. EUROCON-2005*, Vol. 1, pp. 147–150, Belgrade, 21–24 November, 2005.
18. M. Jankovic, B. Reljin, „A new minor component analysis method based on Douglas-Kung-Amari minor subspace analysis method", *IEEE Signal Processing Letters*, Vol. 12, No 12, pp. 859–862, Dec. 2005.
19. V. Radosavljević, N. Kojić, S. Čabarkapa, G. Zajić, I. Reljin, B. Reljin, „An image retrieval system with user's relevance feedback", in *Proc. Conf. WIAMIS-2006*, pp. 9–12, Incheon, Korea, 19–21 April 2006.
20. M. Jankovic, G. Zajic, V. Radosavljevic, N. Kojic, Nikola Reljin, M. Rudinac, S. Rudinac, B. Reljin, „Minor component analysis (MCA) applied to image classification in CBIR system", in *Proc. 8th Conf. NEUREL-2006*, http://neurel. etf. bg. ac.yu, pp. 11–16, Belgrade, Serbia, Sept. 25–27, 2006.
21. S. Rudinac, M. Uscumlic, M. Rudinac, G. Zajic, B. Reljin, „Global image search vs. regional search in CBIR systems", in *Conf. CD 8th Conf. WIAMIS-2007*, pp. 001–004, Santorini, Greece, 6–8 June 2007.
22. S. Rudinac, G. Zajić, M. Ušćumlić, M. Rudinac, B. Reljin, „Comparison of CBIR systems with different number of feature vector components", in *Proc. 2nd Int. Workshop on Semantic Media Adaptation and Personalization*, SMAP-07, pp. 199–204, London, United Kingdom, December 17–18, 2007.
23. G. Zajić, N. Kojić, V. Radosavljević, M. Rudinac, S. Rudinac, Nikola Reljin, I. Reljin, B. Reljin, „Accelerating of Image Retrieval in CBIR System with Relevance Feedback", EURASIP *Journal of Signal Processing*, Spec. Issue on Knowledge Assisted Media Analysis for Interactive Multimedia Applications, Volume 2007 (2007), Article ID 62678, 13 pages.

24. G. Zajić, N. Kojić, Nikola Reljin, B. Reljin, „Experiment with reduced feature vector in CBIR system with relevance feedback“, in *Proc. 5th IET Visual Information Engineering 2008 Conference (VIE'08)*, Xi'an, China, 29 July - 01 Aug, 2008.
25. COST Action IC0604, „Anatomic Telepathology Network (EURO-TELEPATH)“, 2007–2011, http://www.conganat. org/eurotelepath, http://www.cost. esf. org/index. php? id=110&action_number=IC0604
26. B. Reljin, Z. Milošević, T. Stojić, I. Reljin, „Computer tool for detection of microcalcifications in digitized mammograms“, *Workshop on Quantitative Immunohistochemistry in Digital Pathology*, Warsaw, Poland, Nov. 29, 2008.
27. K. Kayser, M. Bogovac, A. Bogovac, J Görtler, G. Kayser, „AI (artificial intelligence) in histopathology – From image analysis to automated diagnosis“, *Workshop on Quantitative Immunohistochemistry in Digital Pathology*, Warsaw, Poland, Nov. 29, 2008.

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