Dr. Murat ÜNEY
Scientist
Centre for Maritime Research and Experimentation
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Profile

Senior researcher with a deep interest and broad experience in probabilistic models and statistical methodology in signal processing, sensor fusion, and, data science. Achievements have included world leading scientific publications and algorithms demonstrated in the pre-commercialisation level.

Research Interests

Probabilistic graphical models, message passing algorithms; Variational methods; Computational statistics (Monte Carlo methods); Scalable/approximate Bayesian inference; Optimisation methods; Space-time stochastic process models in situation awareness and machine perception applications

Research Experience

NATO STO, Centre for Maritime Research and Experimentation
Scientist **February 2018 - present**
Statistical learning and analysis of traffic networks and intent prediction

University of Edinburgh, School of Engineering
Visiting scholar **February 2018 - present**
Statistical inference & learning in signal processing and data science

University of Edinburgh, School of Engineering
Research Fellow **June 2013 - February 2018**
Statistical signal & information processing for multi-sensor fusion

Heriot–Watt University, School of Eng. & Physical Sciences
Research Associate **March 2010 - June 2013**
Distributed data fusion for multi-sensor surveillance

Sabancı University, Signal Processing and Information Systems Lab., İstanbul, Turkey
Graduate Research Assistant **Feb. 2007 - Feb. 2010**
Design of estimators over graphs for sensor networks

Middle East Technical University, Grad. School of Natural & Applied Sciences, Ankara, Turkey
Graduate Assistant **Sept. 1999 - Sept. 2002**
Signal processing and telecommunications, digital signal processing (DSP) software

Software Skills

Prolific in MATLAB and SIMULINK. Python (beginner). Industrial experience in Object Oriented Programming with C++, ANSI C, modular programming, version control tools. Distributed/parallel programming with HTCondor. Linux, Latex, MS Office.

Education

Middle East Technical University, Ankara, Turkey
Ph.d. *in Electrical and Electronics Engineering* **June 2005 - Aug. 2009**
M.Sc. *in Electrical and Electronics Engineering* (CGPA: 3.93/4.0) **Sept. 1999 - Aug. 2001**

Ankara University, Ankara, Turkey
B.Sc. *in Electronics Engineering* (CGPA: 86/100) **Sept. 1995 - June 1999**

Industrial Experience

Iltaren Advanced Technologies Research Group (≈ QinetiQ), Ankara, Turkey
Research and Development Engineer **Jan. 2004 - Feb. 2007**
Analysis, modelling and simulation of electro-optic sensors and sensor platforms (ISO 9001 QA)

Key Research Achievements & Impact

- A novel approximate modelling (pseudo-likelihood) framework utilising **Markov random fields** for solving intractable likelihood problems in multi-sensor multi-object tracking. Proved theoretical results on the approximation accuracy [1, 2, 14, 15, 16, 17, 18] (**UoE**)
- Developed an Object Oriented MATLAB library implementing the proposed **particle belief propagation** approach with the **pseudo-likelihoods** as edge potential functions (**UoE**)
- Awarded a UK DSTL Impact Accelerator grant with Cubica Technology (UK). Successfully demonstrated the proposed **particle message passing algorithms** for sensor network self-configuration on a real network of **radars** and **lidars** using the custom MATLAB library [10] (£**30K** of £**100K**)(**UoE**)
- **PhD thesis** on **estimators over graphs**. Proposed Monte Carlo message passing algorithms for designing estimators constrained by **polytrees** and **bi-partite graphs** while trading off estimation accuracy and communication costs [4, 6](best runner-up in IEEE student paper competition [26]) (URL: http://muratuney.org/PDFs/MuratUneyPhdThesis4.0.pdf)(**SU/METU**)
- Derived information geometry based (viz., Kullback-Leibler divergence (KLD) centroids based) multi-sensor fusion algorithms [5, 21, 23]. Significantly influenced upcoming literature on distributed multi-sensor (**HWU**)
- Attracted follow up grants of £**45K** and £**40K of £100K**, for demonstration on a maritime **radar&camera** sensor suite with BAE Systems and University College London [19] (**HWU**)

Supervision and Teaching

- First supervised PhD research that has proposed a **novel state space model** facilitating efficient computation of statistically efficient detection tests and signature estimation for manoeuvring objects in active sensing [11, 8, 12, 13]. Demonstrated for drone track-before-detect using the novel "holographic radar" of Thales/Aveillant UK (**UoE**)
- Co-supervised post-doctoral work that derived **higher-order statistics of object populations** for sensor fusion applications [3]. Co-developed algorithms for the computation of level of confidence in Bayesian multi-object filtering recursions (**UoE/HWU**)
- Developed and delivered graduate level tutorials on **optimal and adaptive filtering** of stochastic processes and **multi-sensor multi-target filtering (tracking)** in UDRC Summer Schools (**UoE**)
- Assisted in tutorials for undergraduate level probability theory and graduate level estimation theory and Bayesian filtering classes for engineering students (**HWU**)

Professional Activities

- Reviewer for journals IEEE Trans. on Signal Processing, IEEE Signal Processing Letters, IEEE Trans. on Signal and Information Processing in Networks, IEEE Systems, Man, and Cybernetics Part-B, IEEE Trans. on Aerospace and Electronic Systems, Elsevier DSP and Information Fusion
- Served in the technical programme committee (TPC) of International Conference on Information Fusion 2018, 2016, 2015, 2014 and 2013, Sensor Signal Processing for Defence (SSPD) 2017–2014, 2011 and 2010, International Conference on Pattern Recognition (ICPR) 2010.
- Member, IEEE Signal Processing Society, International Society of Information Fusion (ISIF).

Participated Projects

DKOE: Data, Knowledge and Operational Effectiveness (CMRE) **Feb. 2018 - Present**

- Development and analysis of probabilistic models and algorithms for the exploitation of maritime traffic data
- Publication of results in top journals and conferences, collaboration with other scientist in CMRE

UDRC 2 EWP2: Distributed multi-sensor processing (UoE) **June 2013 - Feb. 2018**

- Funded through the UK EPSRC/MOD University Defence Research Collaboration (UDRC) Phase 2 Programme
- Identification of research agenda in multi-sensor signal and information processing
- Publication of results in top journals and conferences

- First supervision of one PhD student, coordination of UDRC researchers

D&S IA: Rapid multi-sensor deployment using automatic calibration (UoE) **August - Dec. 2017**

- De facto principal investigator at UoE
- Demonstration of network self-calibration algorithms developed in UDRC 2 EWP2 on data from a real fusion network of **radars** and **lidars**, in partnership with the first contractor Cubica Technologies

UDRC 1 O02: Distributed target tracking algorithms (HWU) **Apr. 2010 - Feb. 2012**

- Scalable approximations for Bayesian filtering in multi-object multi-sensor problems using *Random Finite Set* models with Dr. Daniel Clark (line manager) and Dr. Simon Julier (University College London) [5, 21, 23]
- Funded through the UDRC Phase 1, attracted two follow-up projects: UDRC/DSTL O18 and CDE/DSTL IND1.
- Provided significant contribution to the follow-up proposals (approx. £45K and £40K for HWU)

UDRC 1 O18: Multi-sensor registration for passive sensors (HWU) **March 2012 - July 2012**

- Named RA, Bayesian filtering with random finite set models for emitter geo-location with passive sensors [20]

CDE/DSTL IND1: Demonstration of Advanced Distributed Tracking Algorithms (HWU) **Aug. 2012 - April 2013**

- Named RA, demonstrated the algorithms developed in UDRC 1 O02 online on real data in TRL 5-6 (pre-commercialisation level) with BAE Systems and UCL [19] through Centre for Defence Enterprise (CDE) funding.

Thesis

PhD Thesis: "Decentralized Estimation Under Communication Constraints" addresses estimator design for distributed sensor networks using Bayesian team decision theory and Monte Carlo methods [6, 4]
URL: http://muratuney.org/PDFs/MuratUneyPhdThesis4.0.pdf
Advisor: Prof. Dr. Kemal LEBLEBİCİOĞLU, METU, EEE Dept.
Co-advisor: Assoc. Prof. Dr. Müjdat ÇETİN , Sabancı University, FENS

M.Sc. Thesis: "Direct and Blind Deconvolution for Multi-Dimensional Signals" generalises a 1-D deconvolution technique to signals with multi-dimensional domains
Advisor: Prof. Dr. Engin TUNCER

Visits, Awards, Achievements

- Aalto University Sensor Informatics and Biomedical Tech. Lab. – Prof. Simo Särkkä (Feb. 2017)
- Ph.D. research awarded best runner-up award in the IEEE Student paper competition in SIU'09 [26]
- Graduate research scholarship at Sabanci University through the European Commission and the Technological Research Council of Turkey (2007-2010)
- Ph.D. Qualification w/ major in signal processing and minor in control systems at METU (3^{rd} in THE BRICS & EE Rankings'15)
- Achieved UK First Class Distinction equivalent CGPAs (UCL grading) for graduate courses on statistical, adaptive, multi–resolution signal processing, dynamical systems theory, optimization, information theory, machine vision and pattern recognition during M.Sc.&Ph.d. studies
- Object oriented MATLAB library for simulating dynamic multiple-object multiple-sensor scenarios, multi-object tracking and various statistical inference algorithms.
- Designed and implemented an ANSI C modem library for the V.32 recommendation of ITU on TI-C54x fixed point Digital Signal Processor (METU) and an ITU T1, T3 codec (BICOM, INC. USA)

Personal Details

- *Hobbies:* Electric guitar playing
- *Languages:* English, Turkish (native), Italian (beginner)

List of Publications

Journal Publications

[1] Murat Üney, Bernard Mulgrew, Daniel Clark, "Latent parameter estimation in fusion networks using separable likelihoods," *IEEE Transactions on Signal and Information Processing Over Networks*, accepted, 2018.

[2] Murat Üney, Bernard Mulgrew, Daniel Clark, "A cooperative approach to sensor localisation in distributed fusion networks," *IEEE Transactions on Signal Processing*, vol. 63, no.5, pp. 1187–1199, March 2016.

[3] Emmanuel Delande, Murat Üney, Jeremie Houssineau, Daniel Clark, "Regional variance for multi-object filtering," *IEEE Transactions on Signal Processing*, vol.62, no.13, pp.3415–3428, July 2014.

[4] Murat Üney and Müjdat Çetin, "Optimization of Decentralized Random Field Estimation Networks Under Communication Constraints through Monte Carlo Methods," *Elsevier Digital Signal Processing*, vol.36, pp. 16–28, November 2014.

[5] Murat Üney, Daniel E. Clark, Simon J. Julier, "Distributed Fusion of PHD Filters via Exponential Mixture Densities," *IEEE Journal of Selected Topics in Signal Processing*, vol. 7, no. 3, pp. 521–531, June 2013.

[6] Murat Üney and Müjdat Çetin, "Monte Carlo optimization of decentralized estimation networks over directed acyclic graphs under communication constraints," *IEEE Transactions on Signal Processing*, vol. 59, no. 11, pp. 5558-5576, November 2011.

Journal Submissions Under Review

[7] Murat Üney, Jeremie Houssineau, Emmanuel Delande, Simon Julier, Daniel Clark, "Fusion of finite set distributions: Pointwise consistency and global cardinality," *IEEE Transactions on Aerospace and Electronic Systems*, under revision (https://arxiv.org/abs/1802.06220).

[8] Kimin Kim, Murat Üney, Bernard Mulgrew, "Detection via simultaneous trajectory estimation and long time integration," *IEEE Transactions on Aerospace and Electronic Systems*, under review (https://arxiv.org/abs/1709.00310).

Conference Publications and Technical Reports

[9] Murat Üney, Leonardo Millefiori, Paolo Braca "Prediction of rendezvous in maritime situational awareness", Fusion 2018, Cambridge, UK, July 2018.

[10] Murat Üney, Keith Copsey, Scott Page, Bernard Mulgrew, Paul Thomas "Enabling self-configuration of fusion networks via scalable opportunistic sensor calibration," SPIE Defence+Security 2018, Orlando, April 2018.

[11] Kimin Kim, Murat Üney, Bernard Mulgrew "Opportunistic synchronisation of multi-static staring array radars via track-before-detect," IEEE ICASSP 2018, Calgary, April 2018.

[12] Kimin Kim, Murat Üney, Bernard Mulgrew, "Simultaneous tracking and long time integration for detection in collaborative array radars," IEEE Radar Conf. 2017, Seattle, USA, May 2017.

[13] Kimin Kim, Murat Üney, Bernard Mulgrew, "Detection of manoeuvring low SNR objects in receiver arrays," SSPD 2016, Edinburgh, UK, September 2016.

[14] Murat Üney, Bernard Mulgrew, Daniel Clark, "Distributed localisation of sensors with partially overlapping field-of-views in fusion networks," Fusion 2016, Heidelberg, Germany, July 2016.

[15] Murat Üney, Bernard Mulgrew, Daniel Clark, "Distributed estimation of latent parameters in state space models using separable likelihoods," ICASSP 2016, Shanghai, China, March 2016.

[16] Murat Üney, Bernard Mulgrew, Daniel Clark, "Maximum likelihood signal parameter estimation via track before detect," SSPD 2015, Edinburgh, UK, Sept. 2015.

[17] Murat Üney, Bernard Mulgrew, Daniel Clark, "Cooperative sensor localisation in distributed fusion networks by exploiting non-cooperative targets," IEEE Workshop on Statistical Signal Processing 2014, Gold Coast Australia, 2014.

[18] Murat Üney, Bernard Mulgrew, Daniel Clark, "Target aided online sensor localisation for bearing only clusters," SSPD 2014, Edinburgh UK, Sep. 2014.

[19] J. Barr, Murat Üney, D. E. Clark, D. Miller, M. Porter, A. Gning and S. J. Julier, "A multi-sensor inference and data fusion method for tracking small, manoeuvrable maritime craft in cluttered regions," the Proc. of the 3rd IMA Conference on Mathematics in Defence. IMA, Malvern, UK, October 2013.

[20] Murat Üney, Daniel E. Clark, Simon J. Julier, "Distributed sensor registration based on random finite set representations," *Proc. of the SSPD 2012*. UDRC, London, UK, Sep. 2012.

[21] Murat Üney, Daniel E. Clark, Simon J. Julier, "On the role of information measures in distributed multi–target tracking," *Proc. of the Int. Conf. on Info. Fusion 2011*, July 2011.

[22] Murat Üney and Müjdat Çetin, "Monte Carlo optimization approach for decentralized estimation networks under communication constraints," *Sabancı University Technical Report*, SU FENS 2010/0007, http://research.sabanciuniv.edu/15985, Nov. 2010.

[23] Murat Üney, Simon J. Julier, Daniel E. Clark, Branko Ristić, "Monte Carlo realisation of a distributed multi–object fusion algorithm," in *the Proc. of the SSPD 2010*. UDRC, London, UK, Sep. 2010.

[24] Murat Üney and Müjdat Çetin, "An Efficient Monte Carlo Approach for Optimizing Decentralized Estimation Networks Constrained by Undirected Topologies," in *the Proc. of the Workshop on Statistical Signal Processing (SSP) 2009*. IEEE, Cardiff, Wales, UK, Aug. 2009.

[25] Murat Üney and Müjdat Çetin, "An Efficient Monte Carlo Approach for Optimizing Communication Constrained Decentralized Estimation Networks," in *the Proc. of the* 17^{th} *EUSIPCO*. EURASIP, Glasgow, Scotland, UK, Aug. 2009.

[26] Murat Üney and Müjdat Çetin,"İletişim Kısıtları Altında Dağıtık Rasgele-Alan Kestirimi (Decentralized Random-Field Estimation Under Communication Constraints)," in *the Proc. of the* 17^{th} *Conference on Signal Processing, Communications, and their Applications (SIU 2009)*. IEEE, Antalya, Turkey, April 2009 (best runner-up for the IEEE student paper competition, in Turkish, available through IEEE Xplorer).

[27] Murat Üney and Müjdat Çetin,"Akustik Algılayıcı Ağlarında Çarpan Çizgeleri Kullanarak Hedef Konumlandırma (Target Localization in Acoustic Sensor Networks Using Factor Graphs)," in *the Proc. of the* 16^{th} *Conference on Signal Processing, Communications, and their Applications (SIU 2008)*. IEEE, Aydın, Turkey, April 2008 (in Turkish, available through IEEE Xplorer).

[28] Murat Üney and Müjdat Çetin, "Graphical Model-based Approaches to Target Tracking in Sensor Networks: An Overview of Some Recent Work and Challenges," in *the Proc. of the Int. Symp. on Image and Signal Proc. and Analysis (ISPA 2007)*. IEEE, İstanbul, Turkey, September 2007.

Dissertation and Thesis

[29] Murat Üney, "Decentralized Estimation Under Communication Constraints," *Ph.D. Thesis*, Middle East Technical University, Ankara, August 2009 (URL: http://muratuney.org/PDFs/MuratUneyPhdThesis4.0.pdf).

[30] Murat Üney, "Direct and Blind Deconvolution for Multi-Dimensional Signals," *M.Sc. Thesis*, Middle East Technical University, Ankara, August 2001.

Other Conferences

[31] Murat Üney and T. Engin Tuncer, "2-D Dizilerin Hatasız Ters-Evrişimi (Exact Deconvolution of 2-D Signals)," in *National Symposium on Signal Processing, Communications and Its Applications (SIU 2002)*, Denizli, Turkey, 2002 (in Turkish).

[32] Murat Üney and T. Engin Tuncer, "Kanal Yankı Giderici için Ters Dönüşümlü Dizilerin Kullanımı (Utilization of Invertible Pseudonoise Sequences for Fast Echo Cancellation)," in *National Symposium on Signal Processing, Communications and Its Applications (SIU 2001)*, Gazi Magusa, 2001 (in Turkish).