Signal and Image processing : data fusion, Artificial Intelligence and ground truth for NDT 4.0

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with the inspirations of

Chi Han Chen, Zdenek Prevorovsky, Valeryi Vengrinovich, Norikazu Ooka, Ward Rummel,
Krishnan Balasubramaniam and Rainer Link
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Academia meeting : Moscow 2010!

Nonlinear Acoustics and Signal Processing for Non Destructive Testing : from Symmetry Analysis to Bimodal Imaging

Dr. Serge Dos Santos, PhD

Associate Professor, Hab. Dir. Rech.

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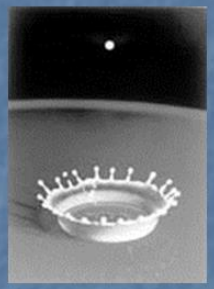

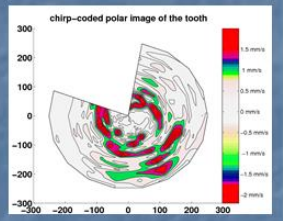

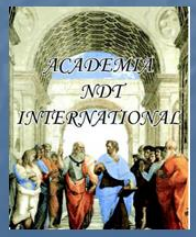

Academia NDT International, General Assembly, June 9 2010, ECNDT2010, Moscow

Academia meeting : Munich 2016 !

The physical meaning of the autocorrelation function in NDT thanks to signal processing

Dr. Serge DOS SANTOS [1], *Hab. Dir. Rech.*
Council Member of Academia NDT International

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19th WCNDT 2016 World Conference on Non-Destructive Testing June 13–17 in Munich Germany

Serge Dos Santos, Academia Meeting, June 15th 2016, Munich, Germany (19th WCNDT)

ERD Gothenburg: ECNDT 2018 !

Nonlinear Signal Processing for NDT 4.0

Serge Dos Santos[1*], Zdenek Prevorovsky[2*], Christophe Mattei[3], Valeriy Vengrinovich[4*], Giuseppe Nardoni[5*]

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12th ECNDT
GOTHENBURG•SWEDEN•2018

For its 10th anniversary, Academia NDT International invites you to attend the European Research Day (June 13th, Room E1)

S. Dos Santos et al, ERD, 12th European conference on Non-Destructive Testing in Gothenburg ECNDT 2018, Sweden, June 11-15, 2018

BEC keynote : October 2018 !

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE

Instituts thématiques Inserm
Institut national de la santé et de la recherche médicale

Systemic multimodal technologies for entering in the NDT 4.0 transition : signal, image, and data for monitoring the health of biological, medical and industrial complex processes

(plenary talk for the 16th Biennial Baltic Electronics Conference, Oct 2018, Estonia)

Serge DOS SANTOS , PhD, Hab. Dir. Rech., *Senior Member IEEE*
(Full Member of Academia NDT International)

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University of Tours, 3, Rue de la Chocolaterie CS 23410, F-41034 BLOIS cedex, France

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Serge Dos Santos, keynote lecture at 16th Biennial Baltic Electronics Conference October 8-10, 2018, Tallinn, Estonia

ENDTCM 2021 keynote : October 2021

Guidance roadmap for Ultrasonic Nonlinear Imaging within Industry 4.0 : the importance of signal, image and data analysis

Serge Dos Santos, *PhD, Hab. Dir. Rech., SM'16 IEEE*
Director of the IIAV (2018-2022)

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Member of the NDE4.0 Ambassador Group
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Serge Dos Santos, keynote lecture, European Conference NDT&CM 2021, October 4-7, Prague

Motivation : Smart Manufacturing or Industry 4.0

- Industry 4.0 : the fourth industrial revolution
- Industry 4.0 is the digital transition of industrial markets, with Smart Manufacturing, internet abilities
- Automated and digital design
- Digital supply chain for better product quality …
- … with automated multi-modal, multi-scales and trans-disciplary NDT

Motivations and Outline

- Introduction
  - The growing interest for nondestructive testing (NDT) and medical imaging based on **nonlinear acoustic effects**
  - Nonlinear ultrasonic (US) has become increasingly important due to the increase of higher sensitivity of electronic instrumentation and its associate **signal processing**
  - Instrumentation for (NDT and aging) **Integrity Engineering** needs basics from applied physics and will concern all disciplines of engineering, including applied mathematics, computer science, modern automation and robotics, big **DATA** and artificial intelligence for **Industry 4.0 and Health 4.0**
- Methodology
  - One of the strategic plan of the international NDT community is to define standards for developing **nonlinear NDT** for **automated set-up** in mass production : **guidance roadmap is necessary**
  - The objective of this study is to improve **numerically** (and experimentally in the future) the modern signal processing for classification of **nonlinear DATA** coming from **multi-modal imaging** techniques
  - The objective of NDT 4.0 is to prepare a guideline for application of **multi-domain techniques**. The working plan is to analyze strengths, weaknesses, opportunities and threats (SWOT) of Artificial Intelligence, Machine learning and Deep Learning within the area of **experimental nonlinear NDT**.
- Conclusions, discussion and perspective

Motivation : Growing need of NDT for Industry 4.0

Growing Need of NDT

- Global Forecast to 2023", the non-destructive testing (NDT) market is expected to be worth **USD 12.06 Billion** by 2023, growing at a CAGR of 7.83% between 2017 and 2023. Factors that are driving the market growth include continuous advancements in electronics, and automation and robotics, growing adoption of IoT solutions, and need to prolong the lifespan and increase the capability of aging assets.

…….Markets & Markets Research

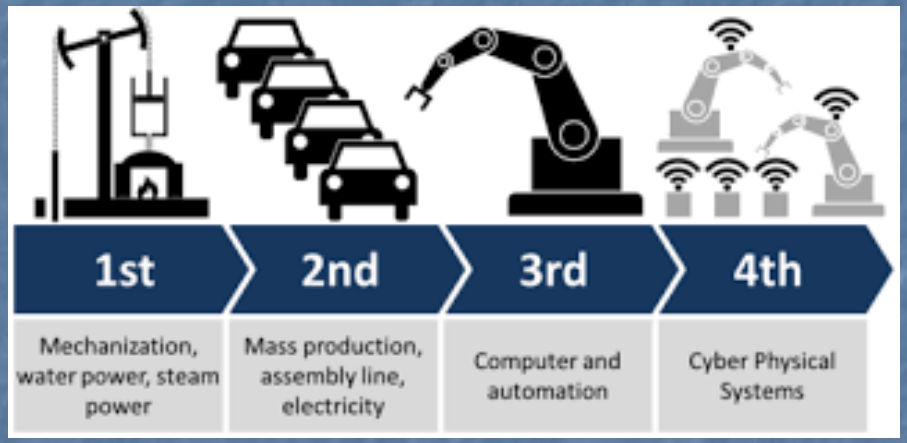
- **NDT is important for new construction or manufacturing, in-service inspection and life extension**

ICNDT
The World Organisation for NDT

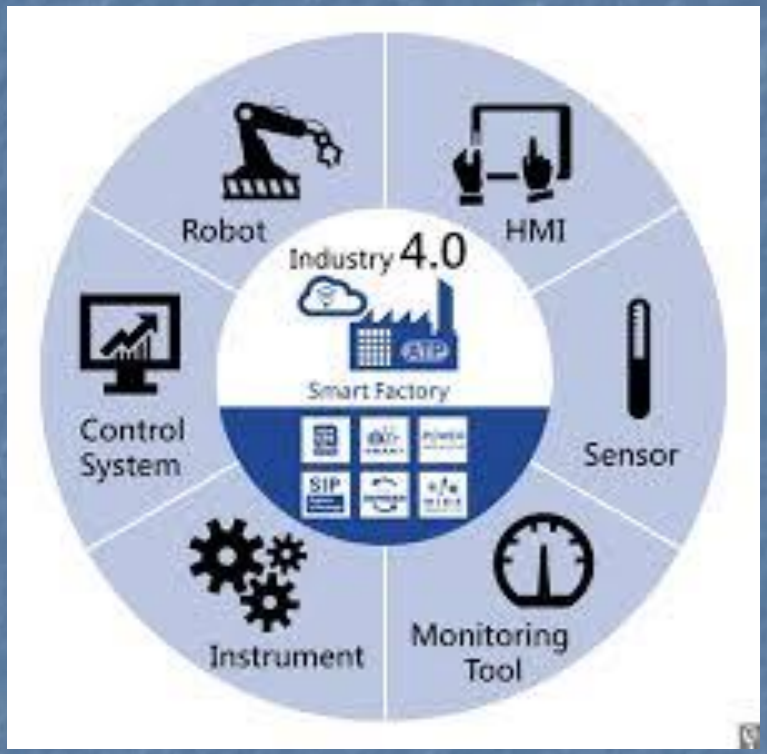
- *Signal and Image processing*
- *Artificial Intelligence*

- *Dr Sajeesh Kumar Babu, Scientific presentation, Academia NDT, Brescia 2018*

Industry 4.0 for NDT 4.0



https://en.wikipedia.org/wiki/Industry_4.0



http://embedded-computing.com

This is time to enter in the era of NDT 4.0 !

See "NDT 4.0 – Overall Significance and Implications to NDT", R. Link and N. Riess, ECNDT, June 2018

Outline

- Introduction
  - The growing interest for nondestructive testing (NDT) methods based on nonlinear acoustic effects
  - nonlinear ultrasonic (US) has become increasingly important due to the increase of higher sensitivity of electronic instrumentation and its associate signal processing algorithms
  - Instrumentation for NDT Integrity Engineering needs basics from applied physics and will concern all disciplines of engineering, including applied mathematics, computer science, modern automation and robotics, big data and artificial intelligence for Industry 4.0
- Methodology
  - One of the strategic plan of the international NDT community is to define standards for developing nonlinear NDT for automated set-up in mass production
  - The objective of this workshop is to define **the future of NDT 4.0** including **modern signal processing tools** such as big data reduction performed with an Artificial Intelligence (AI) and mapping of reduced data for modern NDT
  - The objective of this workshop will be used to prepare a guideline for application of nonlinear techniques. The working plan is to analyze strengths, weaknesses, opportunities and threats (SWOT) within the area of experimental nonlinear NDT.
- Conclusions, Discussion and Perspective

Academia NDT Signal Processing Chapter

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http://www.academia-ndt.org/

Signal Processing for Non Destructive Testing (NDT)

Serge Dos Santos [1,2] and Academia NDT International Members [2]

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Abstract. A review of modern signal processing methods is suggested. All standard NDT methods are described form the signal processing point of view, beginning form historical ideas and systems, and ending with promising modern approaches.

Key words: non destructive testing, signal processing.

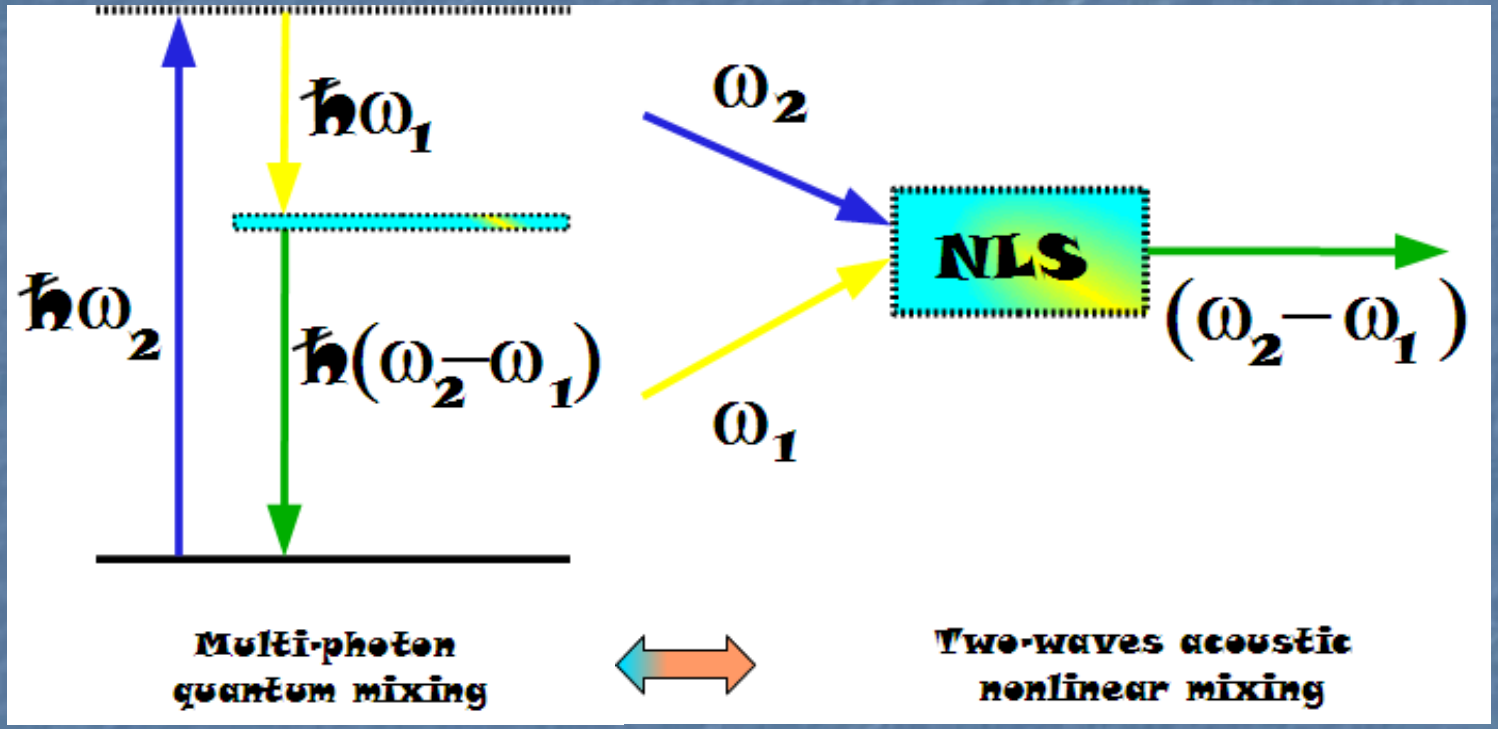
1 Introduction

Chapter supported by

- V. Vengrinovich
- B. Raj
- Z. Prevorovsky
- W. Rummel
- and new members …

Signal processing : a « new » area (Shannon, 1948) compared to mathematics, physics, medicine, chemistry, …

Representation of the nonlinear mixing of waves (optic/acoustic)



(S. Dos Santos, Academia NDT International meeting, Eger, April 2011)

- Symmetries and Lie groups
  - Symmetries and Lie groups
    - Optimisation of the excitation

Motivation : Develop new NDT standards for Industry 4.0

ACADEMIA & ICNDT – RESEARCH TO INDUSTRY

- The ultrasonic testing technique to hold the largest share of the non-destructive testing market. The rapid infrastructural development and aging infrastructure is fuelling the growth of the ultrasonic testing technique in NDT market.
- The market for the manufacturing vertical is expected to grow rapidly between 2017 and 2023. This sector is expected to be driven by government policies and safety awareness for non-destructive testing.
- Academia should identify the priority in needs of Research & support to delivery to Industry
- ICNDT WG3 is a group focused on Education & Research, selective projects from Academia could be transferred to WG3 to reach Industry quicker- Develop Standards, Collaborate with ISO Bodies through TC 135/TC-138 routes as applicable.
- Selective Research works need for the industry could be presented through the WCNDT, An Industry based research developed due to market needs could be delivered by the next conference.

ICNDT
The World Organisation for NDT

- *Signal and Image processing*
- *Artificial Intelligence*

- *Dr Sajeesh Kumar Babu, Scientific presentation, Academia NDT, Brescia 2018*

> Why a calibration is needed ?

Action Plan 4: Education & Research

- *Continue to promote register of Research organisations*
- *Review when to update Research and Education Guides*
- *Prepare a list of NDT books with commentary on their suitability*
- *Draw up a list of Universities offering courses in NDT, categorizing them as in the Guide*
- ***Sponsor International Specialist Groups, each hosted by a Member society***, internet meetings
  - –a) Full matrix capture - BINDT
  - –b) Teraherz imaging – BINDT
  - –c) Microwave NDT – ASNT
  - –d) Magnetic Memory Method- RSSNDT
  - –e) NDT of Art and Heritage - BINDT
  - –f) NDT Reliability – DGZfP
  - –g) Non-linear UT – KSNT
  - –h) Guided Wave UT –KSNT?
  - –ISGs will be open to all members of NDT Societies in ICNDT
- ***Promote more widely ICNDT Guide on importance of NDT and NDT research***
- ***Link to Academia NDT***
  - ***–Offer place for advertising Professorships and Studentships***
- ***Link to WFNDEC***

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Strategic Plan
2016-2020

ICNDT Working Group on NDT Education and Research

ICNDT Working Group 3 is the focal point in ICNDT for activities relating to research, education and links to higher education. At a meeting held during the 19th WCNDT, Dr Manfred Johannes stepped down after four years of service as Chairman and Professor Younho Cho was elected as his successor.

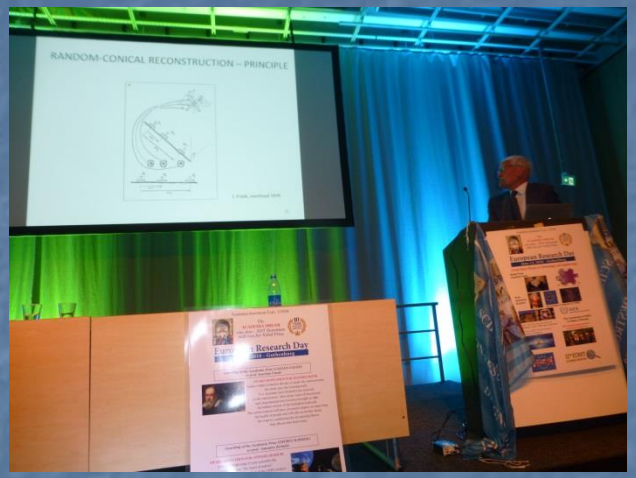
Current members of the ICNDT Working Group on NDT Education and Research are:

- Professor Steve Holland, Iowa State University, USA
- Ekaterina Cheprasova, Russian Society for NDT, Russia
- Professor Vjera Krstelj, Croatian NDT Society, Croatia
- Harold Jansen, SAIW, South Africa
- Professor Marc Kreutzbruck, University of Stuttgart, Germany
- Kevin Smith, ASNT, USA
- Professor Uwe Ewert, BAM, Germany
- Dr Tony Erhard, DGZfP, Germany
- Professors Robert Smith and Keith Newton, BINDT, UK
- Dr Serge Dos Santos, INSA, France
- Mike Farley, ICNDT PGP Chairman.

The calibration is based on the selection of uncertain model parameters and the data that form the calibration metric together with an efficient optimization routine based on measurements

To obtain informative data, the excitation signal is designed to be optimized (sinusoidal, multisinusoidal, frequency chirp, etc.) and the resulting steady-state (linear and nonlinear) response data are measured in order to certify NDT 4.0

Advanced Signal Processing during the Gothenburg European Research Day



Joachim Frank, *Nobel Prize in Chemistry, 2017*

Peter Trampus

Christian Boller

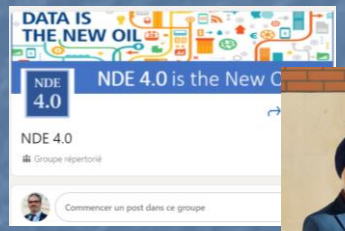
Victor Udintsev

Conclusion and perspectives

- One of the strategic plan of the international NDT community is to define standards for developing nonlinear NDT for automated set-up in mass production
- Like **biological systems**, the material might be equipped with sensors from the beginning of its life, which keep its structural integrity though all information about its **aging** and choosing the optimized way for its expected long life
- The importance of signal, image, data and **modern electronics** (like memristors) has been presented as a basic ingredient for entering in the transition of Industry 4.0 for NDT
- The objective is to define the future of NDT 4.0 including modern signal processing tools such as big data reduction performed with an Artificial Intelligence (AI) and mapping of reduced data for modern NDT
- The perspectives need to include a guideline for application of nonlinear techniques at the muti-domain level in order to trigger such a transition to NDT 4.0

2020 : NDE 4.0 at the ICNDT level

- **Ripi Singh & Johannes Vrana (Facilitators)**
- Alejandro García (Argentina)
- Anish Poudel (USA)
- Bento Alves (Portugal)
- Bernd Valeske (Germany)
- Casper Wassink (Netherlands)
- Don Andrews (Canada)
- Gao Xiaorong (China)
- Krishnan Balasubramanian (India)
- Luigi Feerigni (Italy)
- Makoto Ochiai (Japan)
- Pranay Wadyalkar (Australia)
- Ramon Fernandez (Mexico)
- Rafael Martínez-Oña (Spain)
- Nick Brierley (UK)
- Serge Dos Santos (France)
- Vladimir Syasko (Russia)
- Younho Cho (S Korea)



https://www.youtube.com/c/NDE40 https://www.linkedin.com/groups/12429385/members/

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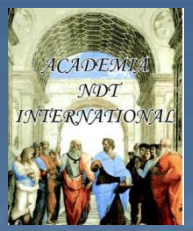
Instituts thématiques Inserm Institut national de la santé et de la recherche médicale



Announcement

https://www.20thwcndt.com/

https://www.icsv28.org/

Thank you !
Questions ?

https://filesender.renater.fr/?s=download&token=f0dad78b-314c-496a-83df-564f21c906a2

Blois castle

Chambord castle

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