Research Methodology

Lecture 2: Research

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Department of Information Engineering
and Computer Science

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We start from a two dimensional approach

- Depth: how deep you will go with respect to a specific aspect of a well defined problem

- Width: how broad is going to be the scientific spectra to which your contribution applies

Both dimensions need attention

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Personal experience

- Bachelor and Master Degree in Telecommunication Engineering **depth**
- PhD in Applied Science – ultrasound wave-propagation modelling **width**

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IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL, VOL. 59, NO. 11, NOVEMBER 2012 2439

Parallel Transmit Beamforming Using Orthogonal Frequency Division Multiplexing Applied to Harmonic Imaging—A Feasibility Study

Libertario Demi, *Member, IEEE*, Martin D. Verweij, *Member, IEEE*, and Koen W. A. van Dongen

***Abstract*—Real-time 2-D or 3-D ultrasound imaging systems are currently used for medical diagnosis. To achieve the required data acquisition rate, these systems rely on parallel beamforming, i.e., a single wide-angled beam is used for transmission and several narrow parallel beams are used for reception. When applied to harmonic imaging, the demand for high-amplitude pressure wave fields, necessary to generate the harmonic components, conflicts with the use of a wide-angled beam in transmission because this results in a large spatial decay of the acoustic pressure. To enhance the amplitude of the harmonics, it is preferable to do the reverse: transmit several**

data acquisition rate is increased by a factor equal to the number of image lines so acquired. The higher data rate can be used to increase the frame rate, to increase the field of view, to produce independent images that can later be averaged to reduce noise, or to reduce the scanning time. In principle, this technique is also applicable to harmonic imaging, e.g., second-harmonic imaging [8]–[11]. However, the demand for high-amplitude pressure wave fields necessary to generate the harmonic components conflicts with

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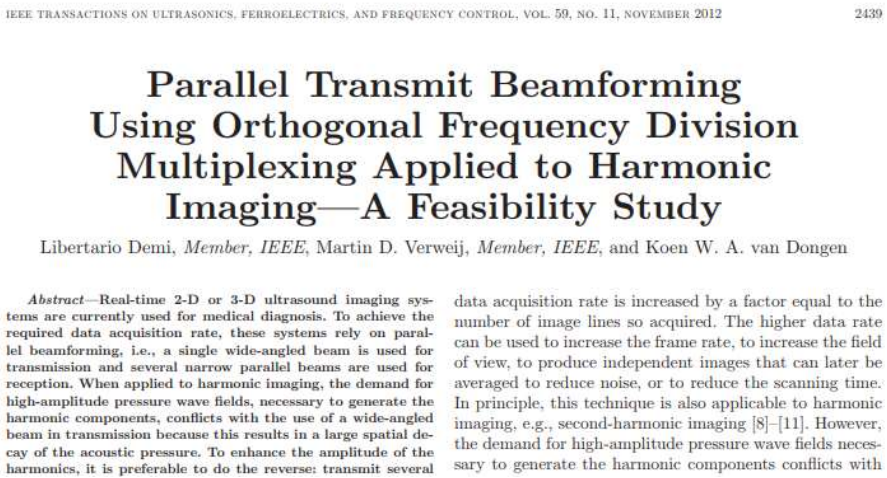

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Thake home messages:

Depth gives you tools
Width gives you the chance to apply the tools

New ideas often comes from boundaries between different areas

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Personal experience

When I first presented this idea, the response was: “it is impossible”

It took me time and effort but I proved that **it was possible** and even useful

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Correspondence

In Vitro and *In Vivo* Tissue Harmonic Images Obtained With Parallel Transmit Beamforming by Means of Orthogonal Frequency Division Multiplexing

Libertario Demi, Alessandro Ramalli, Gabriele Giannini, and Massimo Mischi

***Abstract*—In classic pulse–echo ultrasound imaging, the data acquisition rate is limited by the speed of sound. To overcome this, parallel beamforming techniques in transmit (PBT) and in receive (PBR) mode have been proposed. In particular, PBT techniques, based on the transmission of focused beams, are more suitable for harmonic imaging because they are capable of generating stronger harmonics. Recently, orthogonal frequency division multiplexing (OFDM) has been investigated as a means to obtain parallel beamformed tissue harmonic images. To date, only numerical studies and experiments in water have been performed, hence neglecting the effect of frequency-**

monic imaging at higher data acquisition rate, because focused parallel beams may be used in transmission to increase the amplitude of the generated pressure wave fields.

Harmonic imaging, compared with fundamental imaging, improves the image resolution (in the axial, lateral, and elevation directions), and reduces the effects of clutter, side lobes, and grating lobes [8]–[12], ultimately reducing the influence of the related artifacts, thus improving the image contrast.

When implementing PBT, a possible approach is to spatially distribute the transmitted beams over the volume of interest [13]–[15], and to employ combinations of transmit and receive apodizations [13] or beam transformation techniques [16] to reduce the interbeam interference. Recently, an alternative solution based on orthogonal frequency division multiplexing (OFDM) was presented [17]. With this technique, multiple beams are generated

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We can thus add a third dimension

How do you approach research

- Attitude
  - *Skeptical optimism*
  - *Emotional detachment*
  - *Try to do new things*
  - *Have trust in your own judgment and in the scientific method (try it!)*
- Commitment
  - *Sometimes it may be frustrating*
  - *Sometimes it may be tedious*
  - *Try to always have a clear idea of what you are doing*
  - *Sometimes play*
- Creativity
  - *Not everyone will always welcome your creativity, since to create sometimes implies to destroy. Also remember that creation does not always comes from destruction.*

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What does support creativity?

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- Autonomy
  - *The environment*
  - *Knowing what you know and what you don't know*

- Flexibility and Openness
  - *Challenge your understanding of things*
  - *Be open to different ideas, do not reject things just because you do not understand them*
  - *Look for contamination (**Interdisciplinarity fosters innovation**)*

- Formulation of clear research objectives
  - *Identify the problem (without problems there are no solutions)*
  - *Search a solution (the fact that three is a problem does not imply the existence of a solution)*
  - *Propose a solution (if you fin one)*

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If something that wasn’t there is suddenly there, then creativity was involved

What does defines creativity?

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If something that wasn't there is suddenly there, then creativity was involved

- Originality
  - *It is simply new*
- Usefulness
  - *Basic vs. applied*
- Transformation property
  - *Where you see a problem I see a solution*
    e.g. speckle-noise is used for tissue characterization and motion tracking
- *Condensation property*
  - *At the end of a creative process it is important to answer:*
    1. *What have you done and why?*
    2. *What is the key idea?*
    3. *What characterizes the idea? (e.g. better performance)*

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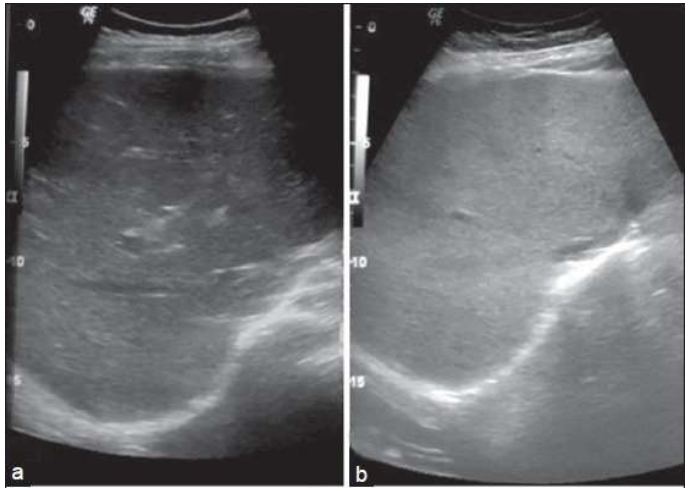

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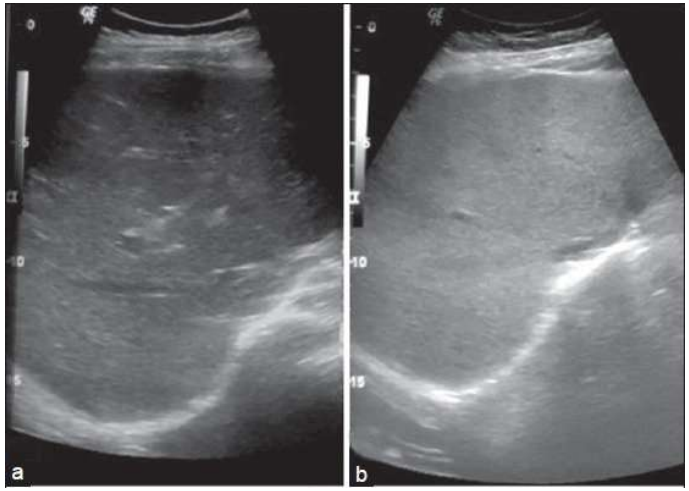

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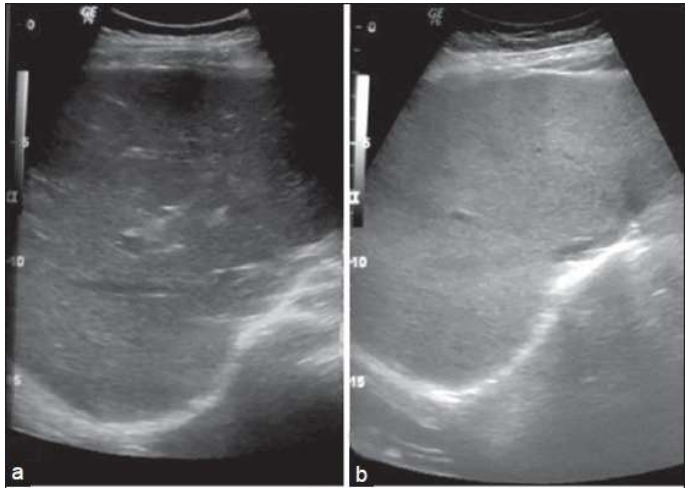

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→ *Thesis Paper*

Making choices

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- Type of research
  - *Basic Research*
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- Type of research
  - *Basic Research*
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- Advisor
  - *Collaborator type*
  - *Hands-off type*
  - *Senior scientist type*

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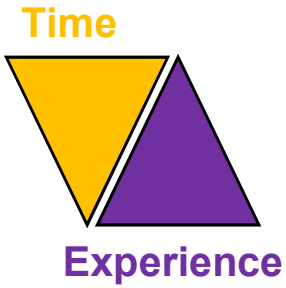

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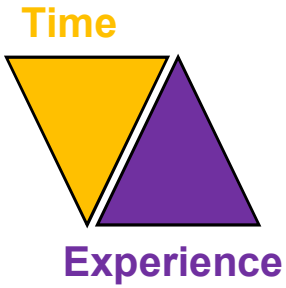

No worries there are exceptions, remember every model is wrong

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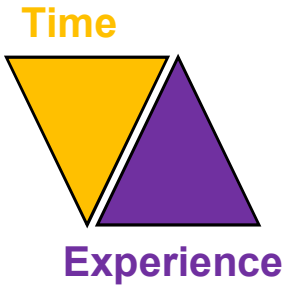

Practical approach:

- *How much one publishes*
- *Where one publishes*
- *How much one is cited*

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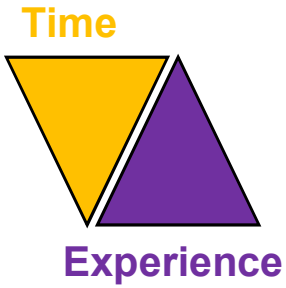
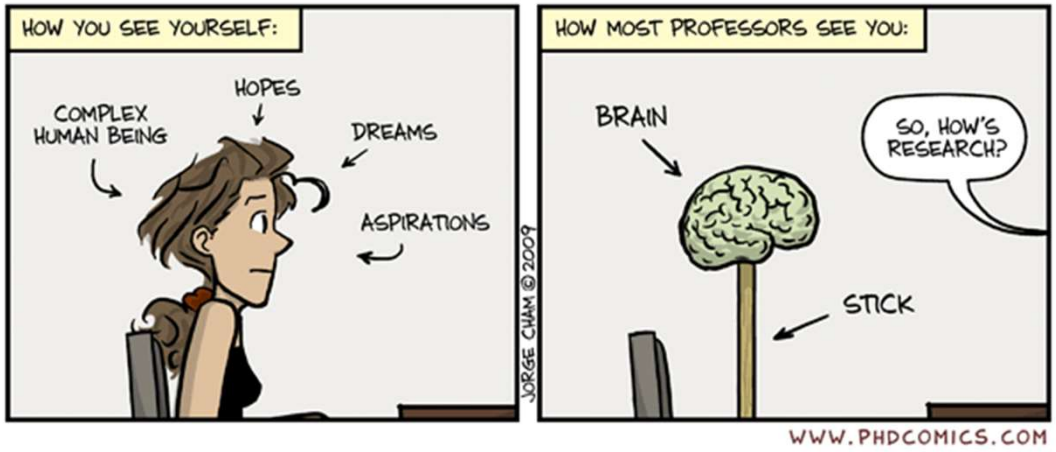


Practical approach:

But also other aspects are of great importance

- *Accomplishments in teaching*
- *Enthusiasm*
- *Management and organization skills*
- *Reputation for setting high standards in a congenial atmosphere*
- *Compatible personality*
- *Ability to serve as a mentor*



Programs of Study

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- Horizontal dimension: *interdisciplinary*
  - *Somewhat harder: there may be no community at all*
  - *Creativity may have more space to be expressed*

- Vertical dimension: *disciplinarily*
  - *Somewhat easier: there is a clear community to identify and address*
  - *Creativity may be more confined to a specific set of problems*

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This is a key factor

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This is a key factor

1. *Set Goals*
2. *Make a to do list and use it*
3. *Beware of time wasters*

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This is a key factor

1. *Set Goals:*
    1. *Passing qualifying*
    2. *Passing Exams*
    3. *Write the thesis*
    4. *Celebrate*

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    1. *Passing qualifying*
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    3. *Write the thesis*
    4. *Celebrate*
    - *Improving horizontal dimension*
    - *Improving vertical dimension*
    - *Seminars*
    - *Solve Research Problems*
    - *Publish papers*
    - *Attend conferences*
    - *Visit other institutions*
    - *Talk to people*

Time Management

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This is a key factor

1. *Set Goals*
2. *Make a to do list and use it:*

    1. *Prioritize your goals*
    2. *You can be flexible with your schedule*
    3. *Realize that tedious may sometimes be necessary*
    4. *Have deadlines and meet them*
    5. *Check your progresses, do not be to easy with yourself*
    6. *Celebrate*

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    - *Focus on the result of an action*
    - *Talk to people*
    - *Link your work to the goal*
    - *Have a To do Book*

Time Management

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This is a key factor

1. *Set Goals*
2. *Make a to do list and use it*
3. *Beware of time wasters:*

    1. *Telephone (PhD killer number one)*
    2. *Lack of deadlines*
    3. *Schedule meetings*
    4. *Procrastination of tedious work (I know I have to do it but I don't do it)*
    5. *Over involvement with details*
    6. *Attempting too much*
    7. *Inability to say no*

Time Management

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This is a key factor

1. *Set Goals*
2. *Make a to do list and use it*
3. *Beware of time wasters:*
    1. *Bad planning*
    2. *Poor communication*
    3. *Lack of celebration*

Time Management

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This is a key factor

1. *Set Goals*
2. *Make a to do list and use it*
3. *Beware of time wasters:*

- *Remember:*
  - *It takes time to focus into a problem*
  - *Interruptions makes it impossible (create a me time-zone)*

PhD Thesis

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Choosing a scientific problem

1. *Can it be enthusiastically pursued and interest can be sustained*
2. *Is it (partly) solvable in 3 years*
3. *Is it worth*
4. *Is it publishable work or only development*
5. *Are you competent for the task, can you become competent*
6. *Do you have what you need to solve the problem*
7. *Will the research prepare you in an area of demand or promise for the future*
8. *Is it special*

In view of the qualifying exam

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Choosing a scientific problem

1. *What?*
    1. *Is it not solved*
    2. *Scenario, user case*
2. *Why?*
    1. *Is it important?*
3. *How?*
    1. *Which approach? Which idea?*
4. *Why me?*
    1. *Which competences do I have? Can I solve this problem individually?*

Timing of PhD

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1st year:

- Review of the literature
- Improve on vertical dimension
- Identify problems which need a solution and structure your work
- Get experienced with public presentations
- Write and submit a (journal) paper
- Pass Qualifying exam

Timing of PhD

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2nd year:

- First intuition(s) of the solution to your research problem
- Execute experiments
- Submit contribution(s) to top conferences
- Visit another institution abroad (make it worth)
- Write and submit a second journal paper

Timing of PhD

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3rd year:

- Deepen your knowledge
- Disseminate your knowledge
- Expand on the previous intuition
- Submit contribution(s) to top conferences
- Write and submit a third top journal paper
- Set the basis for an extension
- Finalize your PhD Thesis

And….

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There is hardly any professional growth without personal growth.

Beauty is essential.

Find motivation for what you do will be of tremendous help.

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End of lecture 2