Research Qualifying Examination (RQE)

A workshop by Helen Xu and Bright Ye

Research Qualifying Examination

~~Robust Quality Estimator~~

(RQE)

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What is the RQE?

Main part: an oral presentation to two faculty members (not your advisor).

RQE: More than a requirement!

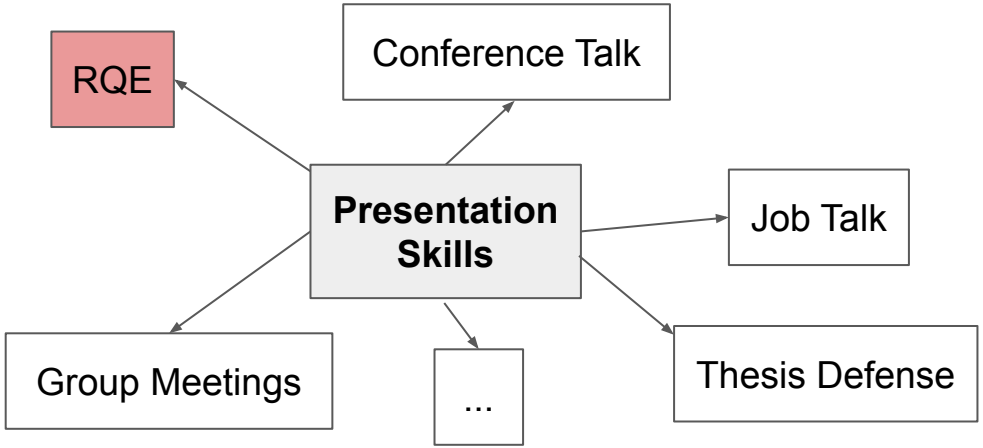
We know it can be stressful!

Overview	Outlining	Slide Design	Questions	Going Virtual

RQE: More than a requirement!

We know it can be stressful!

An opportunity to hone presentation skills:



RQE: Detailed Look

- Departmental requirement for EECS
- Usually taken during 3rd or 4th year

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RQE:

Letter from research supervisor

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Written report on research

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Oral presentation

Overview	Outlining	Slide Design	Questions	Going Virtual

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Oral presentation

Overview	Outlining	Slide Design	Questions	Going Virtual

Selecting a committee is part of the process

Identify 2-3 EECS faculty members.

Your committee doesn't have to be random!

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Schedule your RQE ASAP!

The written report is a research paper

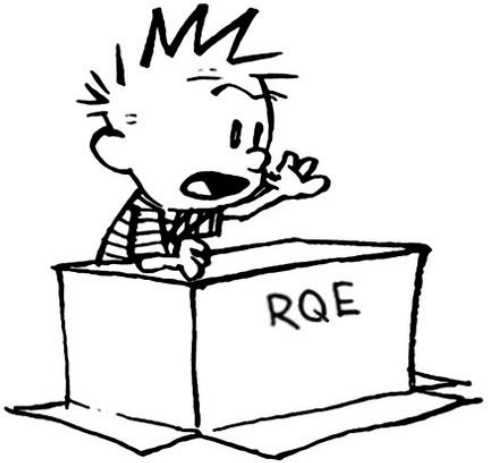
- Focus on topics in the oral presentation
- Often a previous paper (or similar)

The oral presentation is the meat of the RQE

Consists of two parts:

1) Generic research talk (30-45 minutes)
   - Prepare a 30-minute talk
   - Interrupted by questions

2) Questioning period (remaining time)
   - Nature varies by committee



Outlining your RQE Presentation

Overview	**Outlining**	Slide Design	Questions	Going Virtual

What could an initial RQE outline look like?

1. Introduction/Background

2. Problem Statement

3. My Algorithm

4. Results
5. Conclusion and future work

Timing Your RQE

1. Introduction/Background (8 minutes)
2. Problem Statement (8 minutes)
3. My Algorithm (7 minutes)
4. Results (4 minutes)
5. Conclusion and future work (2 minutes)

How to decide how much time to spend?

- Practice sections to test how long they take
- Decide what are the important points to cover.

Tailor your talk to your message: Helen's RQE

1. Introduction/Background (8 minutes)
   a. Sparse Matrices and Tensors
   b. Blocked Formats
2. Problem Statement (8 minutes)
   a. Defining the "fill" (quantity)
   b. Relating the Fill and Block Size
   c. Fill Estimation
3. My Algorithm (7 minutes)
   a. PHIL - randomized algorithm
   b. Theoretical Guarantees
   c. Worked Example
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Tailor your talk to your message: Bright's RQE

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   a. PHIL - randomized algorithm
   b. Theoretical Guarantees
   c. Worked Example
4. Results (4 minutes)
5. Conclusion and future work (2 minutes)

1. Introduction/Background (8 minutes)
   a. Overview of circuit QED
   b. Challenges and Objective
   c. Prior Work in Strong Cross-Kerrs
   d. Preview of Results
2. Formulation of Nonlinear Analysis (7 minutes)
   a. Josephson Junction
   b. Series JJ and External Flux
   c. Parallel Branches
3. Circuit Simulation Results (14 minutes)
   a. Mechanical Analogue
   b. Comparison with Prior Work
4. Conclusions and Future Work (1 minute)

Activity

Think about how you would outline your own RQE presentation. Sketch out the outline.

Shared doc:

https://docs.google.com/document/d/13VBI3fOXD795DQk_qfGxbQ8jqqMG7HH-4ZUM7BN5qLE/edit?usp=sharing

Activity: Outline your own RQE!

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Good Slide Design

Does the content of my slide emphasize the intended message of my slide?

Guiding questions to help you evaluate your slides

Does the content emphasize the message?

Do I have extraneous information?

Is the information understandable?

- Do I need this equation?
- What about this graph?

Does my slide reinforce what I plan to say and vice versa?

Example from Helen's RQE

Prior Work

Previous work has computed the fill exactly and approximately.

Computing the fill is accurate but takes a long time.

OSKI, a heuristic to approximate the fill, is empirically fast and accurate.

However, OSKI lacks theoretical guarantees and may perform poorly on worst-case inputs.

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Unhelpful slide title

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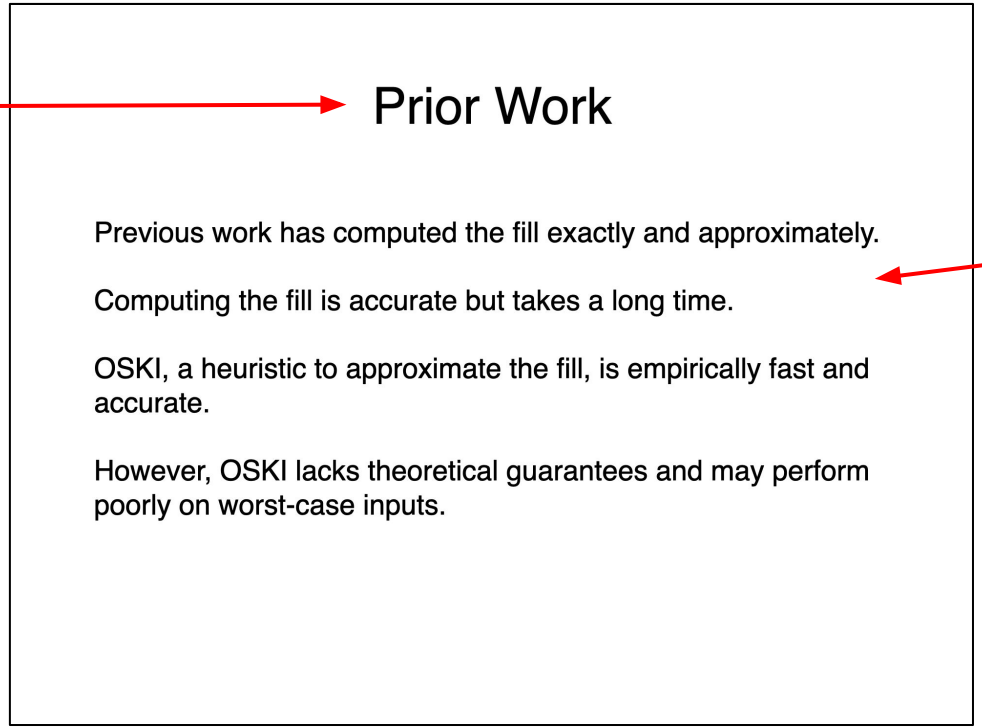
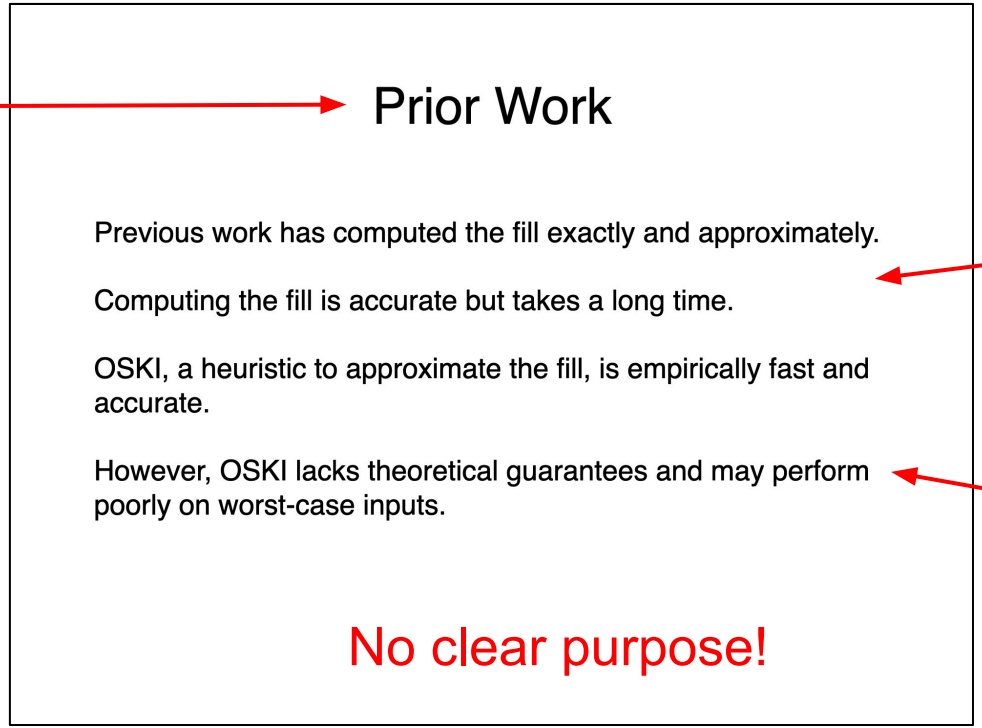


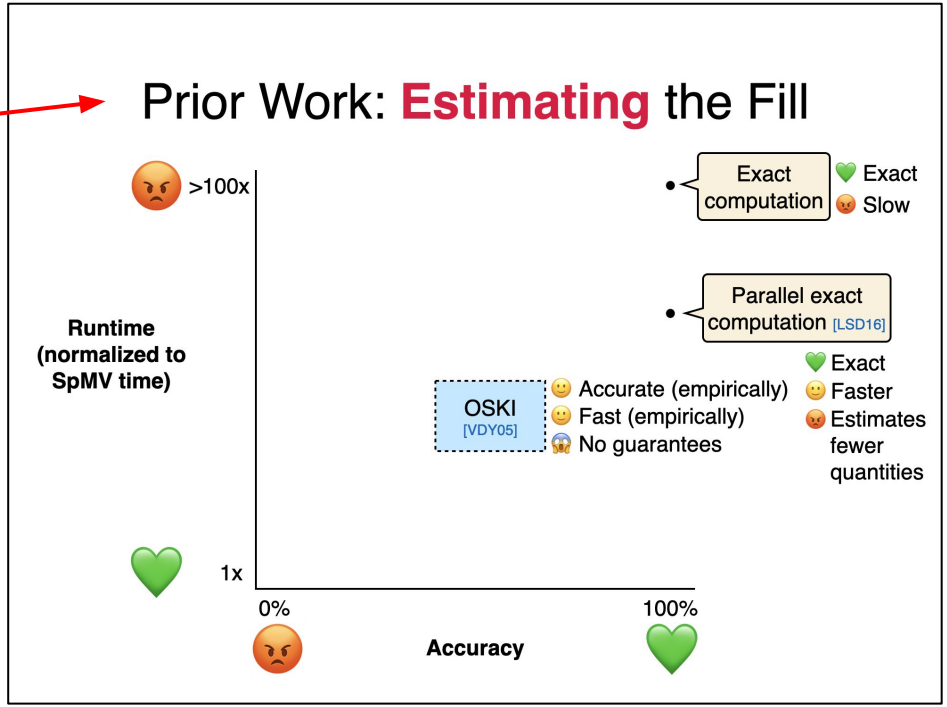
Text only without visualization! Could benefit from a diagram

Example from Helen's RQE



Example from Helen's RQE (Revised)

Descriptive title with purpose



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Descriptive title with purpose

Concise: evaluation metrics

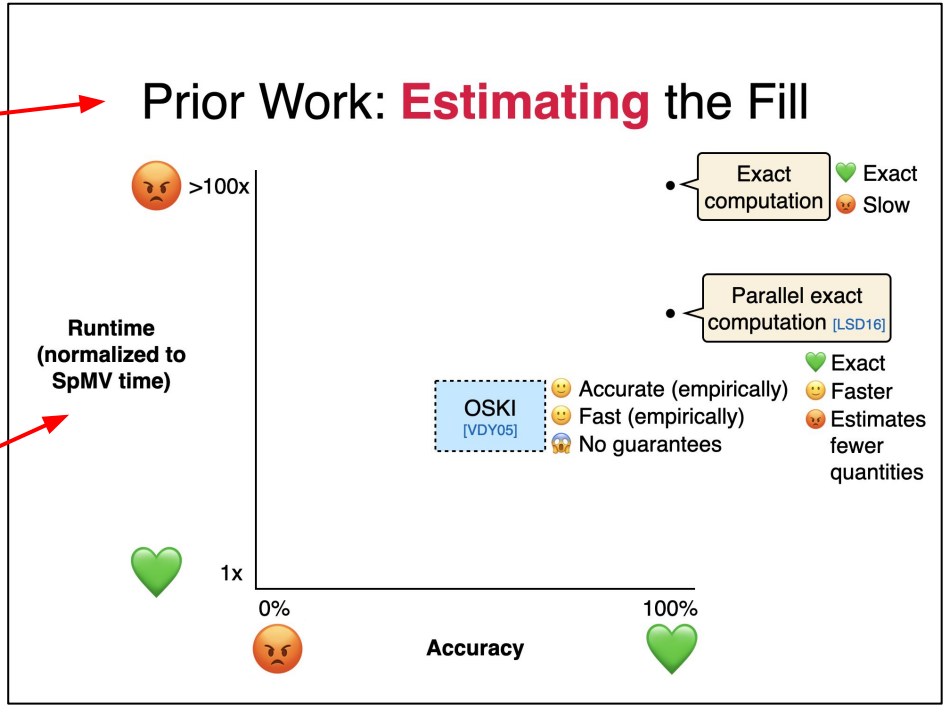

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Diagram provides visualization of relationship between algorithms

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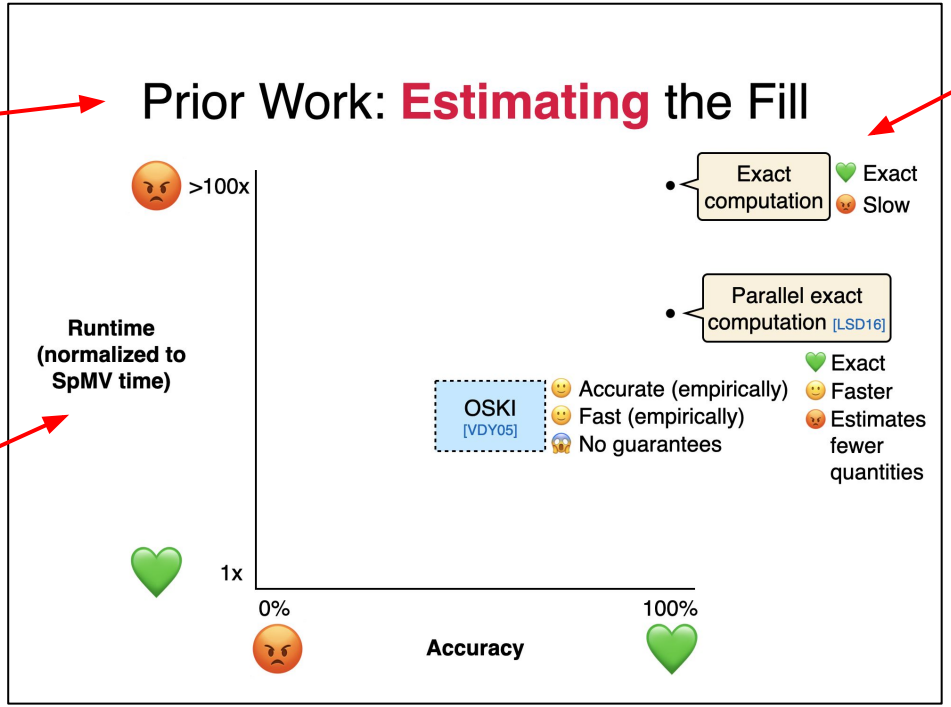

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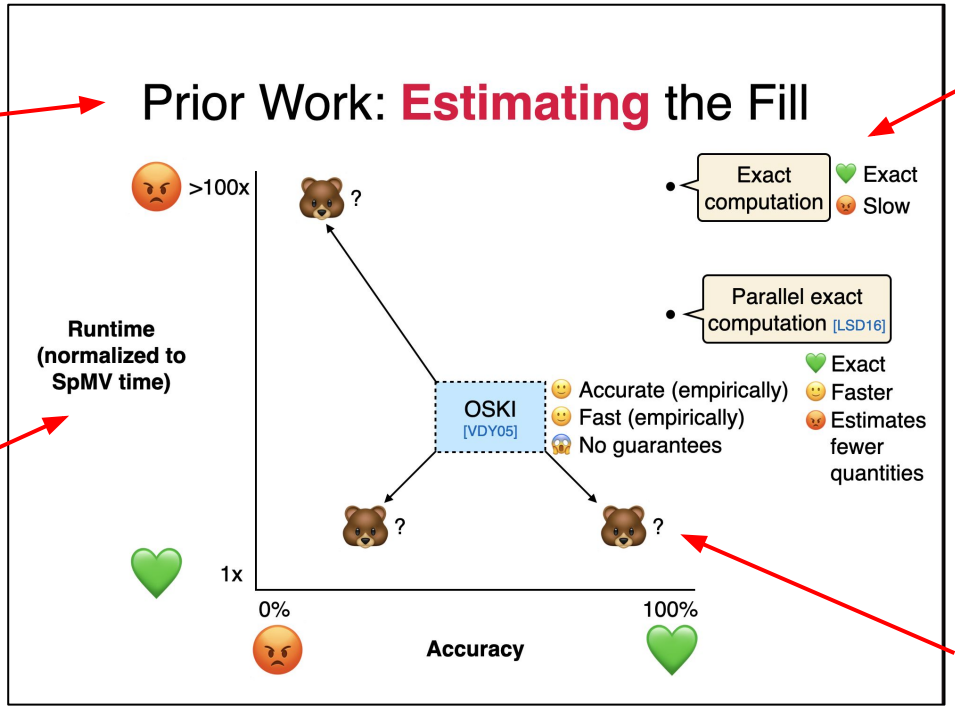


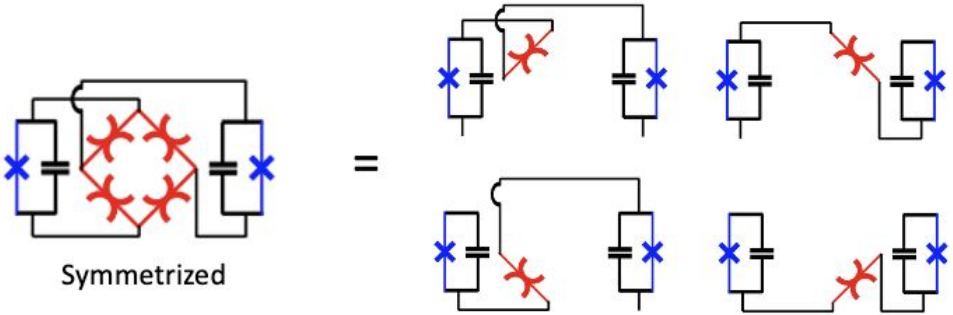
Concise: evaluation metrics

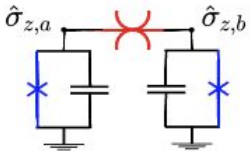
Illustration of algorithm properties

Example

Quarton ring modulator (QRM)

- Inspired by JRM





$$E_Q(\phi_a - \phi_b)^4 = E_Q[\phi_a^4 + \phi_b^4 + 6\phi_a^2\phi_b^2 - 4(\phi_a^3\phi_b + \phi_a\phi_b^3)]$$

Self-Kerr cancellation | Cross-Kerr χ | Cancelled by symmetry

- Residual capacitance, imperfect quarton inductance all cancelled as well

Example

Quarton ring modulator (QRM)

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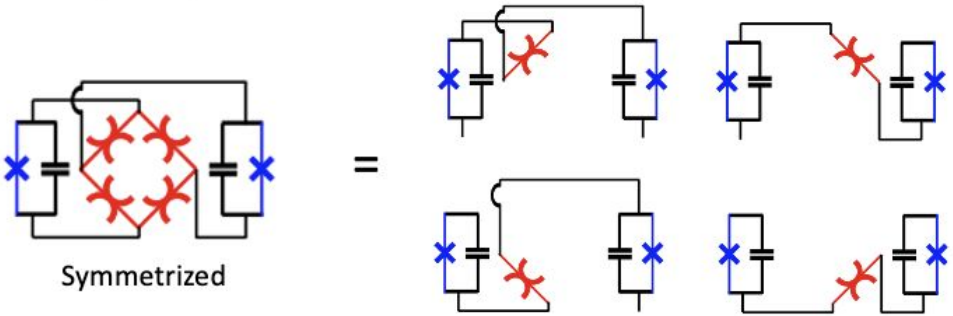

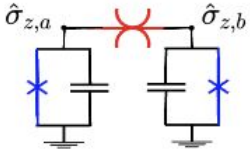

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Self-Kerr cancellation | Cross-Kerr χ | Cancelled by symmetry

- Residual capacitance, imperfect quarton inductance all cancelled as well

Activity:

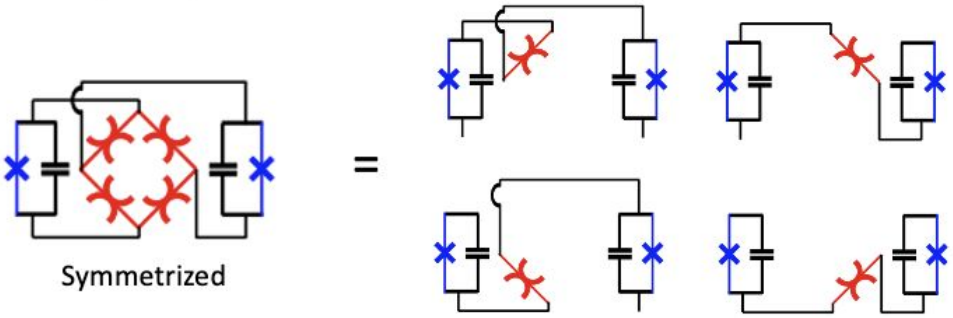
- Take a few minutes to think about issues with this slide's design!
- Write your ideas in https://bit.ly/3ncJInK

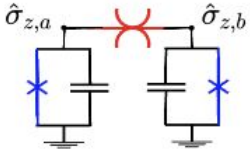
Example

Quarton ring modulator (QRM)

← Unhelpful title

- Inspired by JRM





Connection not obvious

$$E_Q(\phi_a - \phi_b)^4 = E_Q[\phi_a^4 + \phi_b^4 + 6\phi_a^2\phi_b^2 - 4(\phi_a^3\phi_b + \phi_a\phi_b^3)]$$

Self-Kerr cancellation | Cross-Kerr χ | Cancelled by symmetry

← Buried message

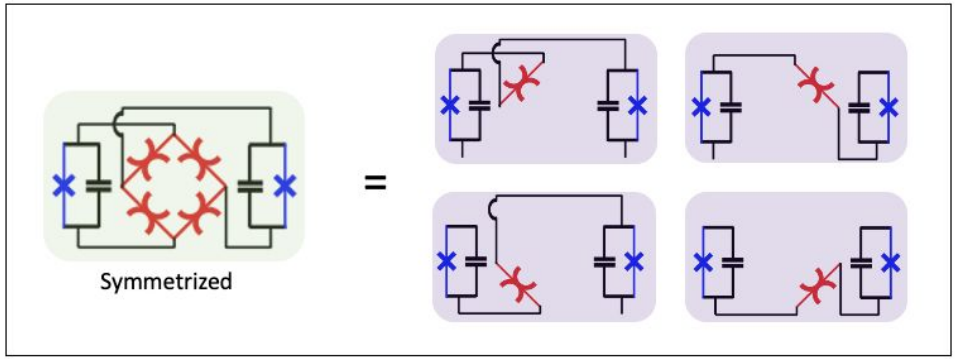
- Residual capacitance, imperfect quarton inductance all cancelled as well

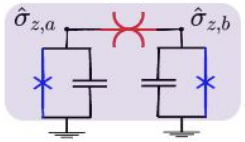
Example (revised)

Quarton ring modulator (QRM) cancels anti-symmetric coupling

← Title is message

Explicit figure boundary draws clear distinctions





Use of color shading to draw visual connection

Figure: Decomposition of QRM coupling circuit into combinations of canonical coupling circuit

$$E_Q[\phi_a^4 + \phi_b^4 + 6\phi_a^2\phi_b^2 - 4(\phi_a^3\phi_b + \phi_a\phi_b^3)]$$

Cancelled by QRM symmetry

↑ emphasized message

- Notice that minor points were discarded
  - Could prepare a slide with this in case committee asks

Example

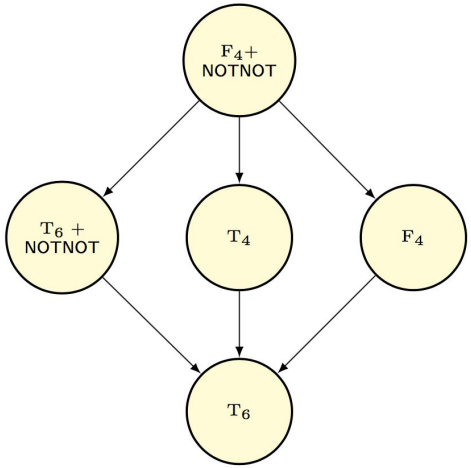
Sporadic Classes in the Affine Sublattice

$$\mathrm{T}_k(x) = \begin{cases} x & |x| \equiv 0 \pmod 2 \\ \overline{x} & |x| \equiv 1 \pmod 2 \end{cases}$$

$$\mathrm{T}_4 = \begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

$$\mathrm{F}_k(x) = \mathrm{T}_k(x) \oplus 1^k$$

$$\mathrm{NOTNOT}(x, y) = x \oplus 1, y \oplus 1$$



	mod 2	mod 4	orthogonal
T_6	✓	✓	✓
T_4	✓	✗	✓
F_4	✓	✓	✗
$\mathrm{T}_6 + \mathrm{NOTNOT}$	✓	✗	✗
$\mathrm{F}_4 + \mathrm{NOTNOT}$	✓	✗	✗

Example

Sporadic Classes in the Affine Sublattice

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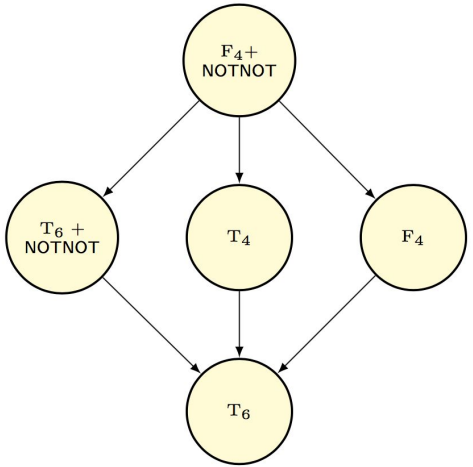


Many definitions to parse

	mod 2	mod 4	orthogonal
T_6	✓	✓	✓
T_4	✓	✗	✓
F_4	✓	✓	✗
$\mathrm{T}_6 + \mathrm{NOTNOT}$	✓	✗	✗
$\mathrm{F}_4 + \mathrm{NOTNOT}$	✓	✗	✗

← Buried message

Example (revised)

Invariants yield number theoretic properties of gates

Theorem (Summary)

Every class of gates is characterized by a corresponding set of invariants.

Idea for classification: The intersection of two gate classes is described by the intersection of their invariants.

For example:

- Affine gates that also preserve Hamming weight mod k?
- Non-affine gates which preserve inner products mod 2?

Title is message

Remind audience of setup

Present intuitive reasoning

Give examples

Example (revised)

Invariants yield number theoretic properties of gates

Extra space allows addressing more interesting aspects

	mod 2	mod 4	mod 8	orthogonal
T_6	✓	✓	✗	✓
T_4	✓	✗	✗	✓
F_4	✓	✓	✗	✗
$T_6 + \mathrm{NOTNOT}$	✓	✗	✗	✗
$F_4 + \mathrm{NOTNOT}$	✓	✗	✗	✗
CNOTNOT	✓	✗	✗	✗

Table: Affine gates which preserve Hamming weight mod 2.

Table stresses results to be communicated

- Notice that definitions of gates were removed entirely
  - Could prepare a slide with this in case committee asks

Example from Maz's RQE

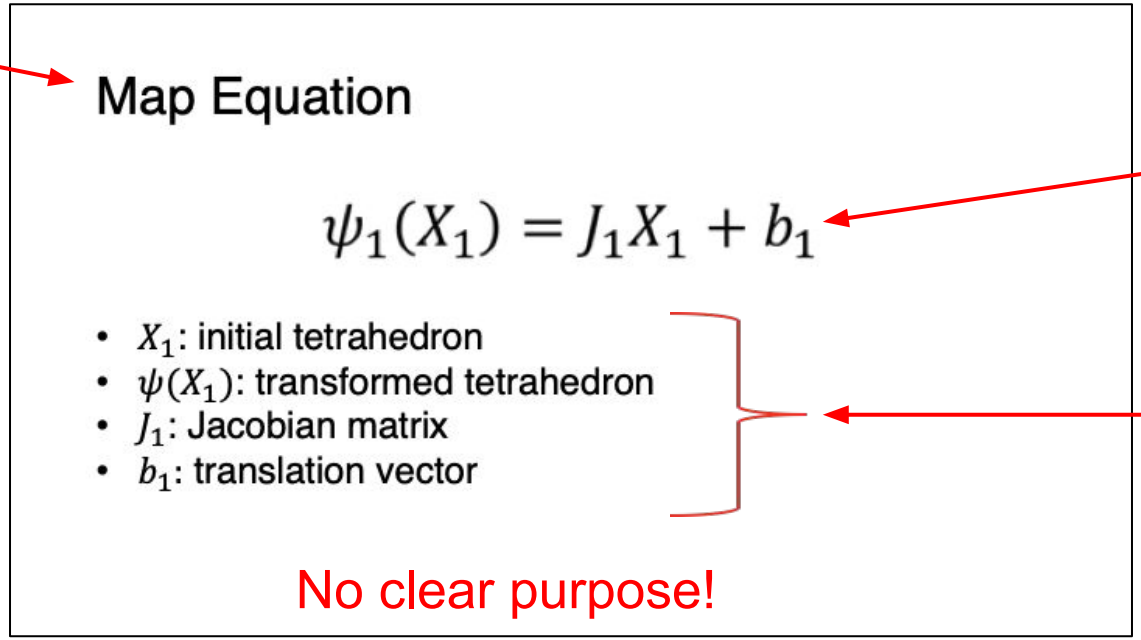
Map Equation

$$\psi_1(X_1) = J_1 X_1 + b_1$$

- X_1: initial tetrahedron
- $\psi(X_1)$: transformed tetrahedron
- J_1: Jacobian matrix
- b_1: translation vector

Example from Maz's RQE

Unhelpful slide title



Equation without context

Hard to parse. Can benefit from a diagram

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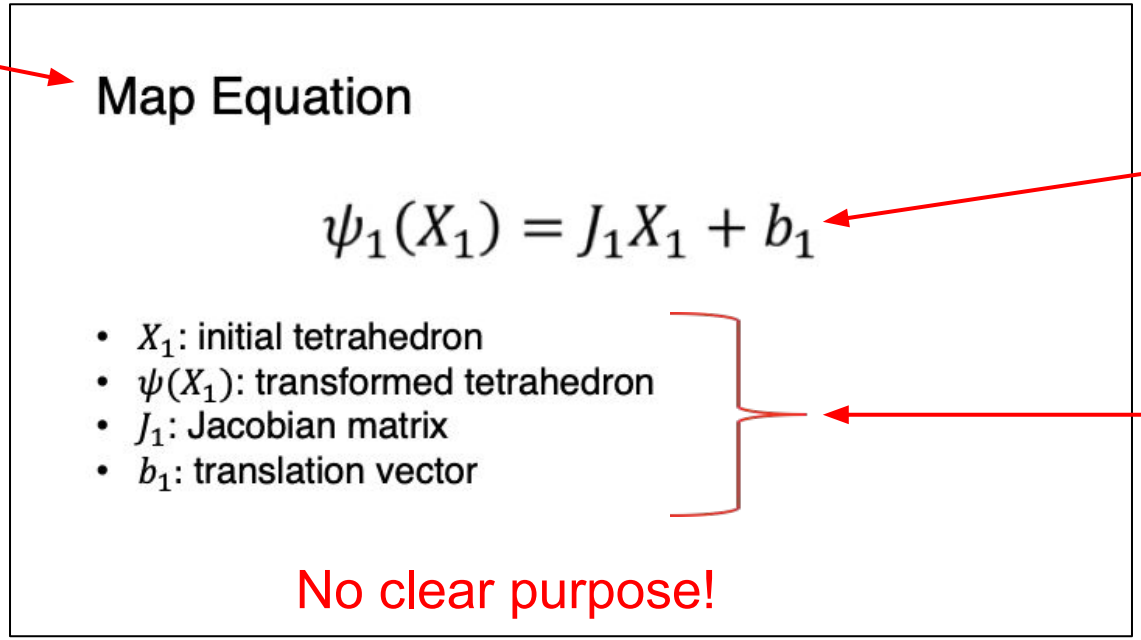

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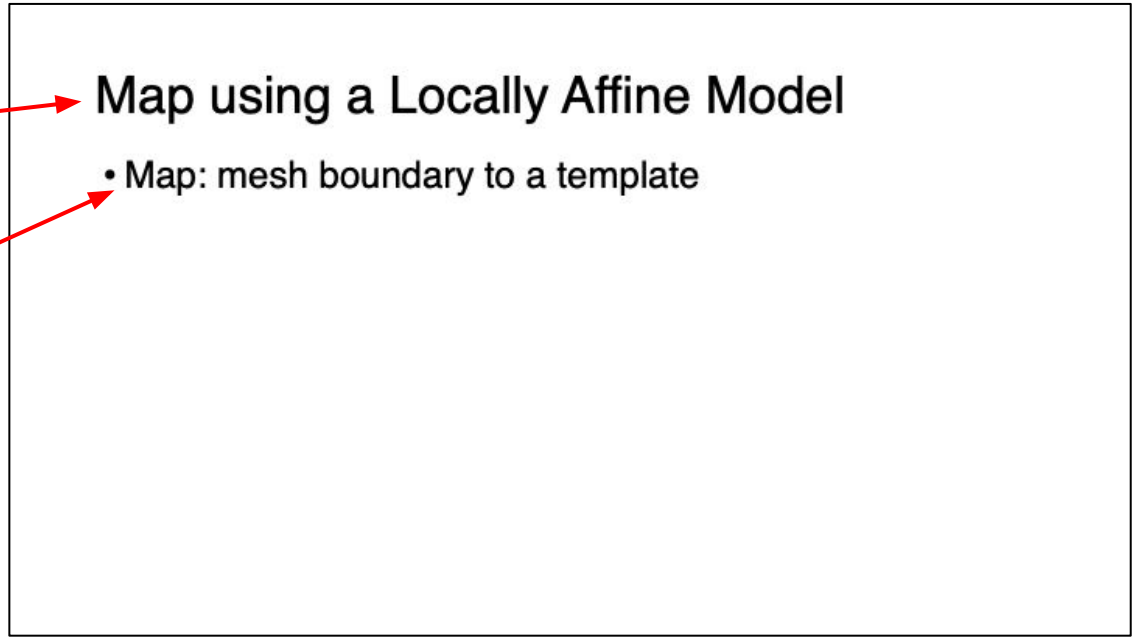
Example from Maz's RQE (Revised)

Descriptive title with purpose

Concise: inputs and outputs



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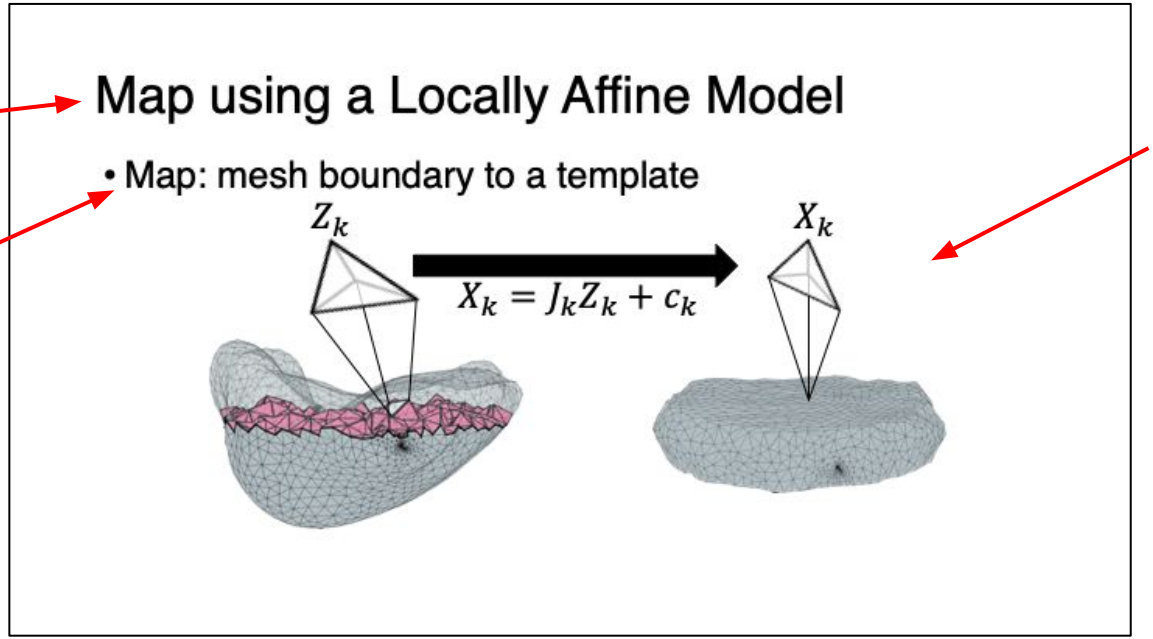


Diagram with real data provides context for equation and variables

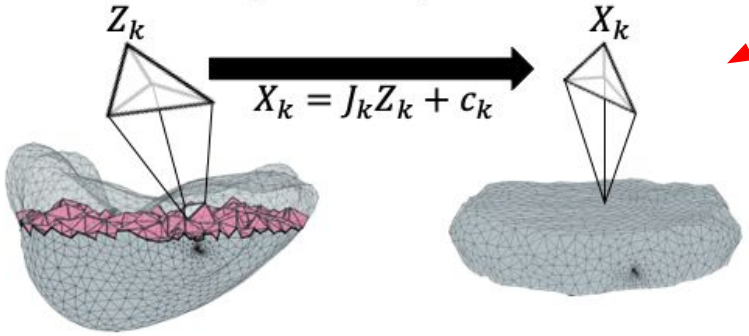
Example from Maz's RQE (Revised)

Descriptive title with purpose

Concise: inputs and outputs

Map using a Locally Affine Model

- Map: mesh boundary to a template



$Z_k \in \mathbb{R}^{3\times4}$: tet k in original space, $X_k \in \mathbb{R}^{3\times4}$tet k in flattened space,
$J_k \in \mathbb{R}^{3\times3}$: Jacobian of transformation

Diagram with real data provides context for equation and variables

Details for RQE examiners

Answering Questions

“I panic every time someone asks me a question.”

Take your time before answering

Think about your answer. Take deep breaths!

Take your time before answering

Think about your answer. Take deep breaths!

Ask for clarification if you need it.

Other practical advice

Pivot questions into things you can have an answer for. Don’t just say no.

- “Why didn’t you compare to <method you’ve never heard of before>?”
  - Answer: “Unfortunately, I’m not familiar with that exact method, but we did compare to something similar, let me tell you about it…”

Other practical advice

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Practice in front of a technical audience (your labmates, your adviser, an EECS Comm Lab Fellow, etc.). Encourage them to ask questions.

Be aware of common questions

- What are the applications of your thesis?
- How is your method different from XYZ?
- What happens if we change this criterion to ABC?
- What are possible future directions you could take this?

Some examples of specific questions

- Have you tried an elastic FEM approach instead of an optimization one? (Maz)
- Did you try using curvature to segment the boundary? Why is spectral clustering appropriate for this task? (Maz)
- On your results slide, why does your graph go down at that point? (Rohan)
- How long does it take this system to train? Do you have any ideas for how you could improve that? (Rohan)

Some examples of specific questions

- Would variable block size affect the results? Can you extend your algorithm to non-fixed block sizes? (Helen)
- Have you considered matrix reordering? How would reordering affect the algorithm? (Helen)
- Would higher order coupling affect the results? (Bright)
- How valid is the harmonic oscillator basis for analysis? Have you tried using phase or charge basis? (Bright)

Activity

Think of four questions you could be asked in your RQE, and how you would answer them. Have two “smaller-scope” questions (e.g., “why did you use X method here”) and two “larger-scope” ones (e.g., “what do you plan to do next in this line of work”).

Use https://bit.ly/2QVL5Lh

Giving a Virtual RQE: Best Practices 1

- Enthusiasm is key!
  - Lack of visual feedback is challenging.

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- Keep it organic. Don’t read off your slides just because you can.

- Make sure you have an appropriate background.
  - Test your background in advance!

Not that appropriate...

Overview	Outlining	Slide Design	Questions	**Going Virtual**

Giving a Virtual RQE: Best Practices 2

- Have water nearby before you start.

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- Dress as if you're delivering an in-person presentation.

Giving a Virtual RQE: Best Practices 2

- Have water nearby before you start.
- Dress as if you're delivering an in-person presentation.
- Give a practice Zoom talk to your labmates, a friend, or the Comm lab.
  - Ask them to verify that they can see your face properly. You should be facing the camera directly.
  - Ask them to check the audio quality. Can you hear each other well?

Good luck in your RQE!

For all your RQE/presentation needs, the EECS Communication Lab is here to help!

We offer virtual appointments and can help you give a practice RQE run in realistic conditions.

Schedule an appointment at:

http://mitcommlab.mit.edu/eecs/

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Pick a time on our online scheduler!

http://eecs.mywconline.com/

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