Velocity in Research

CS 197 & 197C | Stanford University | **Sean Liu** & Lauren Gillespie
cs197.stanford.edu | cs197c.stanford.edu

Slides adapted from previous iterations of the course by Michael Bernstein


We Are CSE
Nadia Polikarpova

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Administrivia

197

Due Thurs 5/4, 10am:

Assignment 4: Progress Report II

Discuss milestone in advising meeting

197C

Due Thurs 5/4, 10am:

Assignment 3: Introduction

Propose timeline for achieving milestone

Administrivia

197: Milestone — half-way checkpoint of your project

- CAs will scope out a milestone for your team
- Expectations: 10 hrs / week / member
- Goal: help pace your progress

No extensions on group assignments.

Administrivia

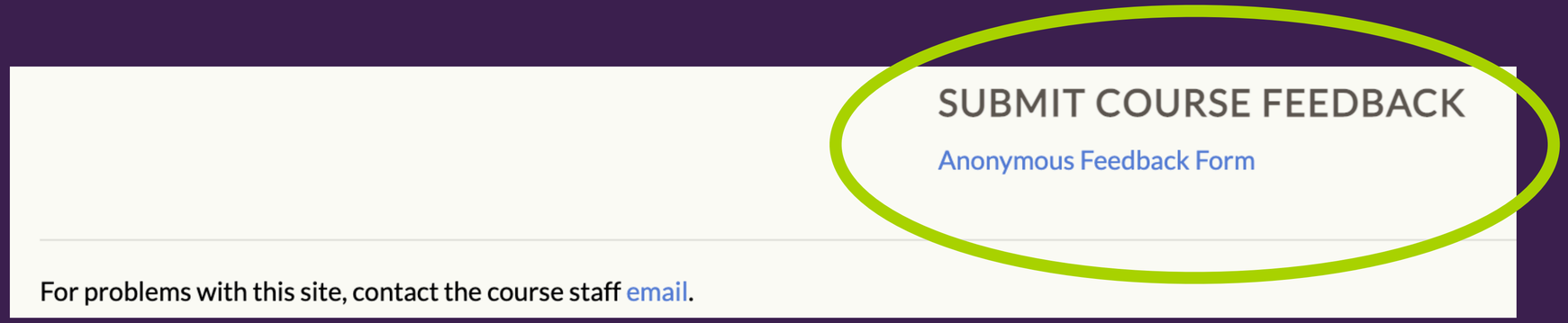
197: Each team member is expected to contribute equally

- Team Dynamics Check-in Form (once mid-point, once at the end)
- In the case of substantially imbalanced contribution, we will adjust participation grades to compensate
- If your team is experiencing issues, please:
  - Talk to each other first
  - Inform your CA

Anonymous Feedback

Option 1: High-resolution course evaluation (polled by email)

Option 2: Go to course website; scroll to bottom



Week 4 Feedback

197: More regular check-ins?

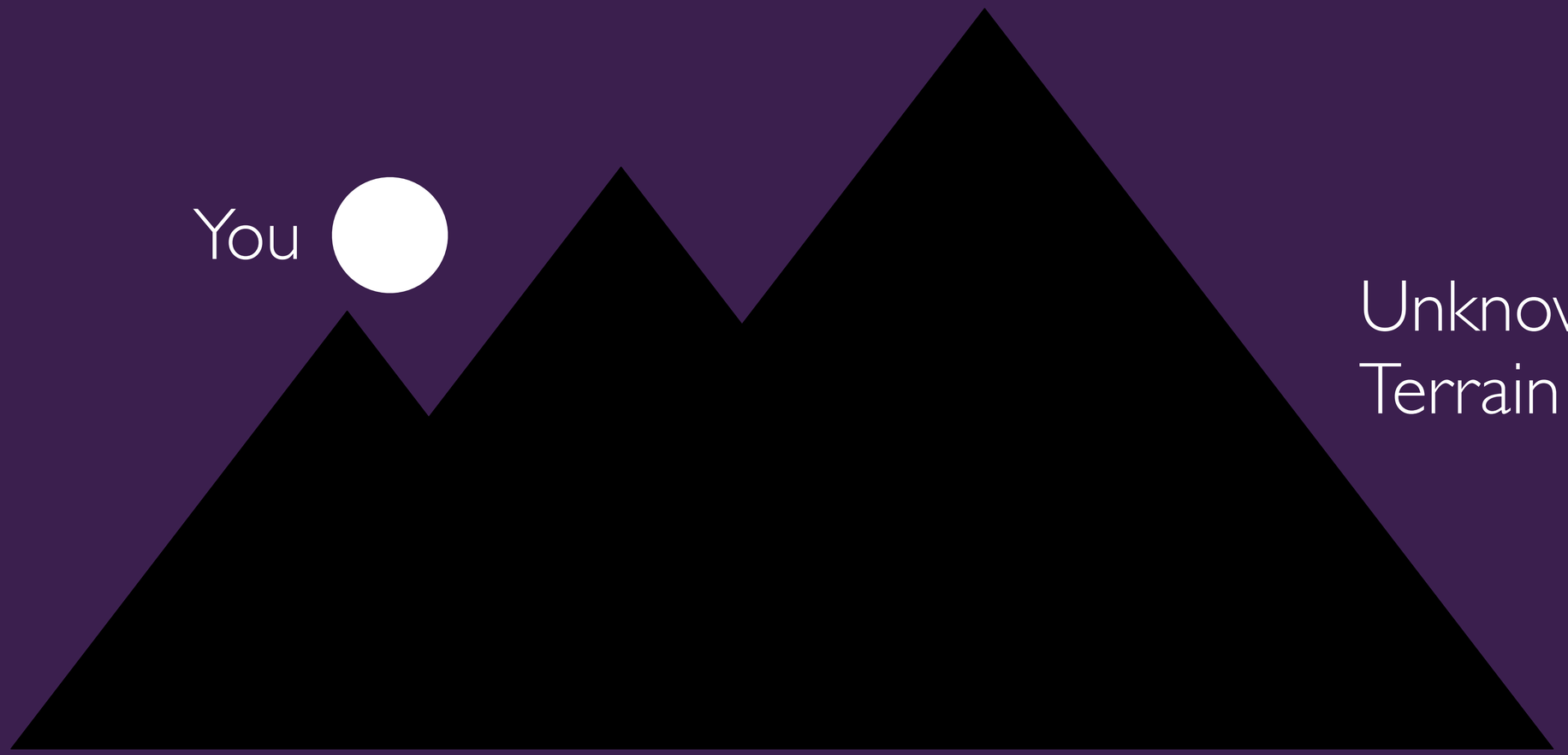
- Synchronously (1-2 per week):
  - Advising meeting
  - Schedule your team meetings during OH
- Asynchronously: Email your CA (please follow communication guidelines)
  - HCI: 197-hci@cs.stanford.edu
  - AI + CompBio: 197-compbio@cs.stanford.edu
  - AI for sustainability: 197-sustain@cs.stanford.edu
- If your team is experiencing issues, please let your CA know ASAP

Week 4 Feedback

197C:

- Picking a research direction for purposes of the writing assignment
  - Writing is a **very** important skill you need as a researcher!
  - RW: help you think critically and propose a direction.
  - A direction is better than no direction.
  - Not set in stone! You're welcome to change it later.
- 15 papers is time-consuming
  - Strategy: don't read the full paper — practice skimming!
  - We can re-calibrate if necessary. Expectation: 10 hours per week on assignment or milestone

From last time…



From last time…

Vectoring

What problem are we solving?

"Research is so much slower than industry."

"I feel like we're just not getting anywhere."

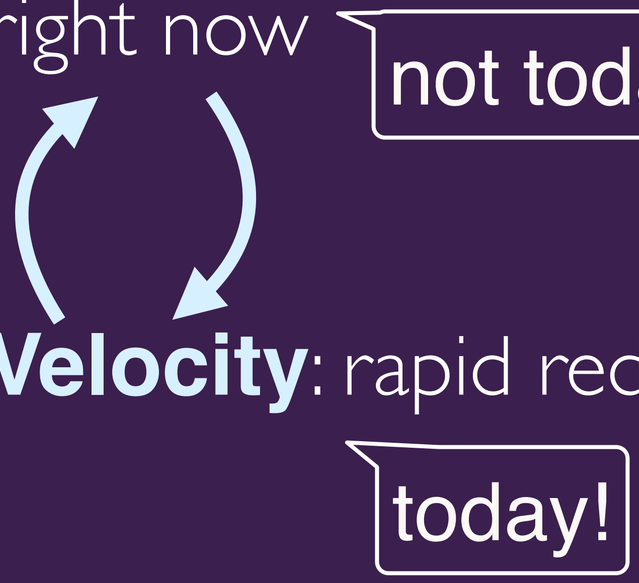
"This keeps dragging on and it's not working. I'm losing motivation."

"I missed another submission deadline. I think my advisor is starting to lose faith."

Bernstein theory of faculty success

To be a Stanford-tier faculty member, you need to master two skills that operate in a tight loop with one another.

Vectoring: identifying the biggest dimension of risk in your project right now



Velocity: rapid reduction of risk in the chosen dimension

Today's big idea: velocity

What is research velocity?

How do we achieve high velocity?

What other signals do people mistake for velocity?

What Is Velocity?

Problematic point of view

"Research is so much slower than industry."

"I feel like we're just not getting anywhere."

"I missed another submission deadline."

We're not making enough progress.

What research is not

1. Figure out what to do.
2. Do it.
3. Publish.

What research is

Research is an iterative process of exploration, not a linear path from idea to result [Gowers 2000]

Michael's diagnosis: The Swamp

"I have led and advised many projects at this point, and I can now say with certainty: nearly every project has a swamp." — Michael Bernstein

The Swamp: challenges that get the project stuck for an extended length of time

- Model not performing well
- Design not having intended effect
- Engineering challenges keep cropping up
- &etc

Photo by Big Cypress National Preserve

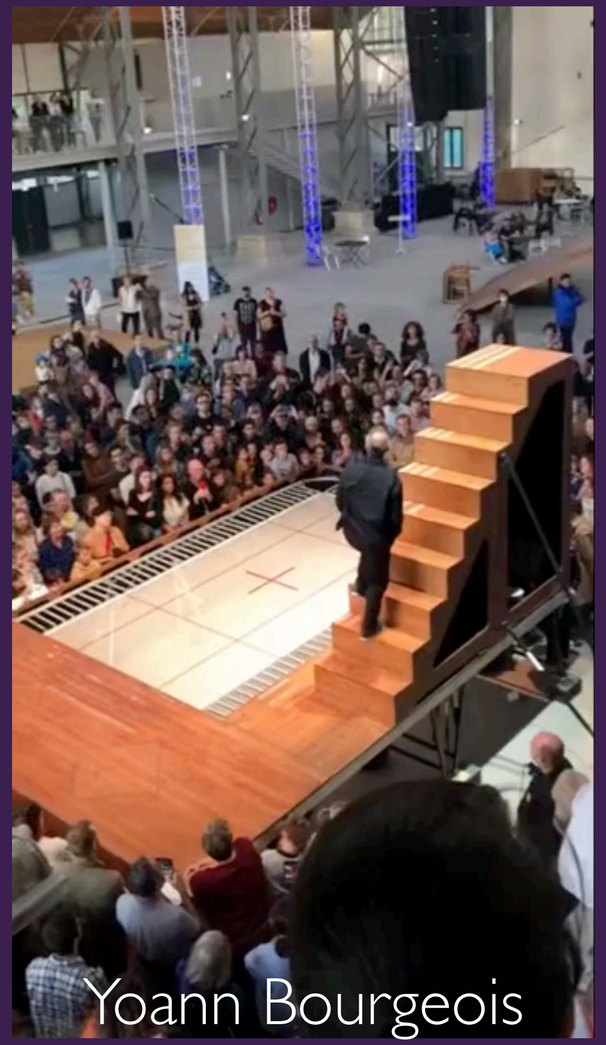
No progress :(

Swamps make progress a poor measure

Swamps can make a project appear to have no or little progress for an extended period of time.

However, swamps are when you need to be at your most creative. You need to try many different ideas, and rapidly, to orienteer your way out of a swamp.

The difference between an amazing and a merely good researcher: **how effectively and rapidly you explore ways to escape the swamp**.


Yoann Bourgeois

Enter velocity

Drawn from theory and practice of rapid prototyping

- Buxton, Sketching User Experiences
- Schön, The Reflective Practitioner
- Houde and Hill, What Do Prototypes Prototype?
- CS 247 (cs247.stanford.edu)

“Enlightened trial and error succeeds over the planning of the lone genius.” - Tom Kelley

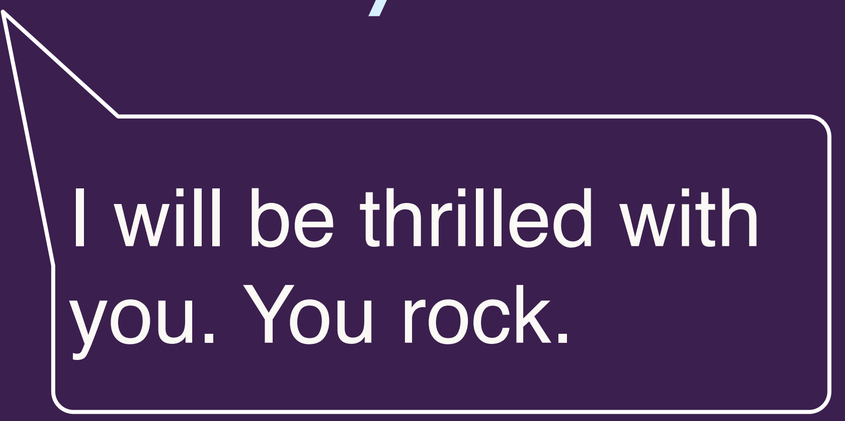
Velocity vs. progress

Progress is an absolute delta of your position from the last time we met. How far have you gotten?

Velocity is a measure of the how much you've learned in that time.

If you tried a ton of creative different ideas and they all failed…

that's low progress
but high velocity



High velocity :)

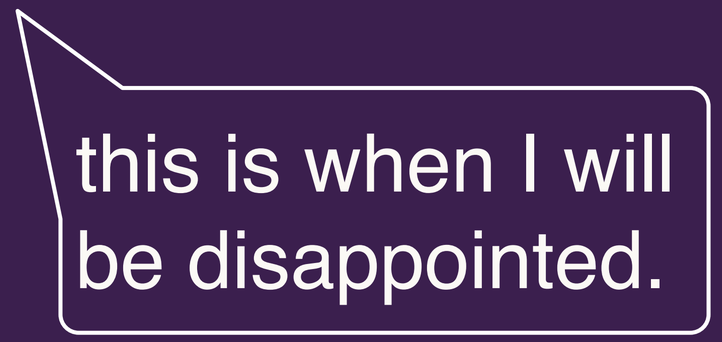
Why is velocity a better measure?

Because we have likely learned a ton from the failures along the way.

Because we likely needed to experience those failures to eventually get to a success: you're learning the landscape.

Because the worst outcome is not failure, but tunneling unproductively.

That's low progress
and low velocity



How do I achieve high velocity?

Restating our goal, precisely

We have a question to answer this week: Will our hunch work in a simple case? Is assumption X valid? Will this revised model overcome the problematic issue? Can we write a proof for the simple case? We've chosen this week's question that we're trying to answer carefully.

Velocity is the process of answering that question as rapidly as possible.

Choosing this question is the process of vectoring.

Approach: core vs. periphery

Achieving high velocity means sprinting to answer this week's question, while minimizing all other desiderata for now.

This means being clear with yourself on what you can ignore:

Core: the goal that needs to be achieved in order to answer the question

Periphery: the goals that can be faked, or assumed, or subsetted, or mocked in, so we can focus on the core.

Core-periphery mindset

The week's goal is **not a demo**.

> But this means working on everything both in the core and in the periphery.

The week's goal is instead an **answer to a question**.

> To answer a question, you don't need to address all the issues in the periphery. Just focus on what's in the core.

Core-periphery mindset

Your approach should be, necessarily, incomplete.

Be rapid. Be **ruthless**. Strip out or fake everything not required to answer the question.

Velocity

Experimental design: Make strong assumptions about everything that's in the periphery

- Use an easy or smaller subset of the data, make simplifying assumptions while working on your proof, ignore other nagging questions for the moment

Research Engineering: Do minimal engineering to answer your question (vector)

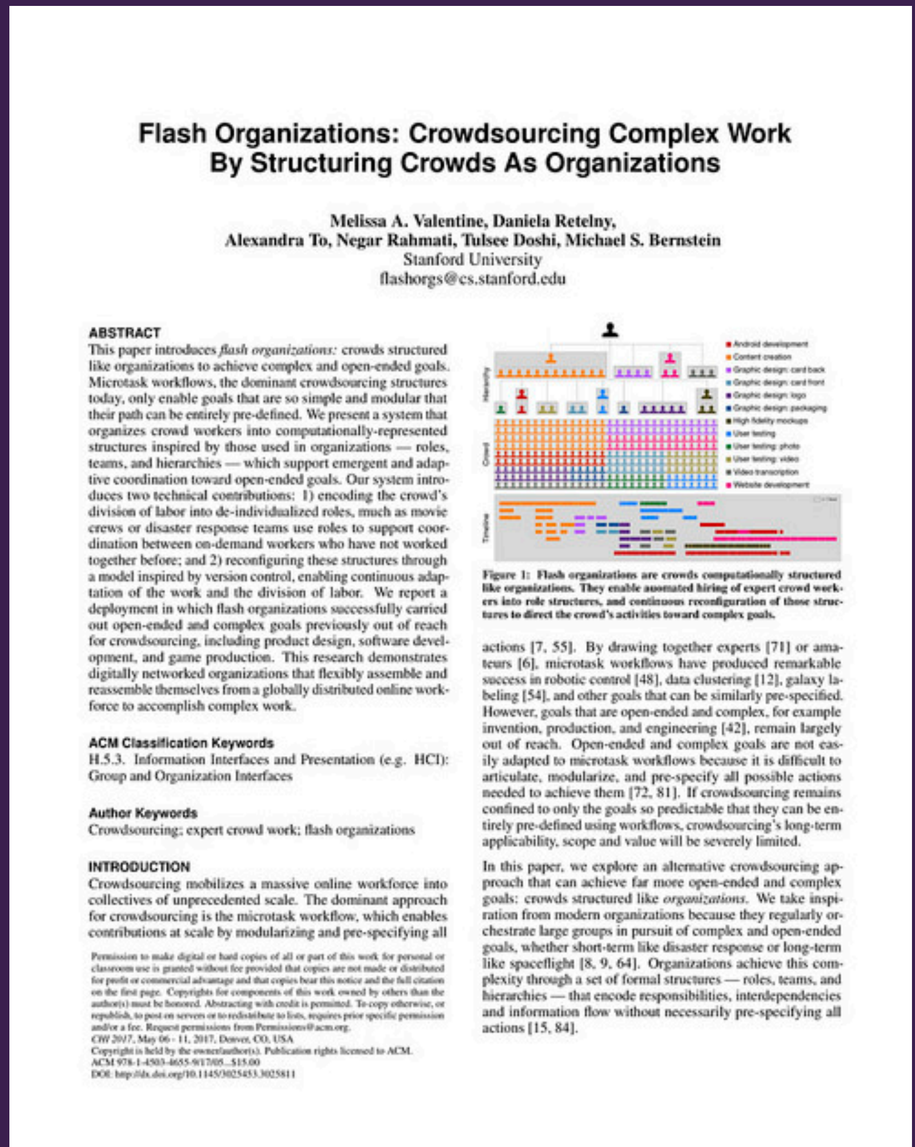
- Find simple workarounds if original plan is taking long, mock in data

Social debugging: flash organizations

Problem: We had a problem of online workers not being as good as their Upwork profile suggested. We wanted workers who were experts at Angular, Django, UI, UX, marketing, etc, but often in practice they were not as good as they advertised.

We had a hunch that giving workers ~1 hr starter tasks would allow us to vet them.

How do we test this hunch?



Flash Organizations: Crowdsourcing Complex Work By Structuring Crowds As Organizations

Melissa A. Valentine, Daniela Retelny,
Alexandra To, Negar Rahmati, Tulsee Doshi, Michael S. Bernstein
Stanford University
flashorgs@cs.stanford.edu

ABSTRACT
This paper introduces *flash organizations:* crowds structured like organizations to achieve complex and open-ended goals. Microtask workflows, the dominant crowdsourcing structures today, only enable goals that are so simple and modular that their path can be entirely pre-defined. We present a system that organizes crowd workers into computationally-represented structures inspired by those used in organizations — roles, teams, and hierarchies — which support emergent and adaptive coordination toward open-ended goals. Our system introduces two technical contributions: 1) encoding the crowd's division of labor into de-individualized roles, much as movie crews or disaster response teams use roles to support coordination between on-demand workers who have not worked together before; and 2) reconfiguring these structures through a model inspired by version control, enabling continuous adaptation of the work and the division of labor. We report a deployment in which flash organizations successfully carried out open-ended and complex goals previously out of reach for crowdsourcing, including product design, software development, and game production. This research demonstrates digitally networked organizations that flexibly assemble and reassemble themselves from a globally distributed online workforce to accomplish complex work.

ACM Classification Keywords
H.5.3. Information Interfaces and Presentation (e.g. HCI): Group and Organization Interfaces

Author Keywords
Crowdsourcing; expert crowd work; flash organizations

INTRODUCTION
Crowdsourcing mobilizes a massive online workforce into collectives of unprecedented scale. The dominant approach for crowdsourcing is the microtask workflow, which enables contributions at scale by modularizing and pre-specifying all

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DOI: http://dx.doi.org/10.1145/3025453.3025811

Figure 1: Flash organizations are crowds computationally structured like organizations. They enable automated hiring of expert crowd workers into role structures, and continuous reconfiguration of those structures to direct the crowd's activities toward complex goals.

actions [7, 55]. By drawing together experts [71] or amateurs [6], microtask workflows have produced remarkable success in robotic control [48], data clustering [12], galaxy labeling [54], and other goals that can be similarly pre-specified. However, goals that are open-ended and complex, for example invention, production, and engineering [42], remain largely out of reach. Open-ended and complex goals are not easily adapted to microtask workflows because it is difficult to articulate, modularize, and pre-specify all possible actions needed to achieve them [72, 81]. If crowdsourcing remains confined to only the goals so predictable that they can be entirely pre-defined using workflows, crowdsourcing's long-term applicability, scope and value will be severely limited.

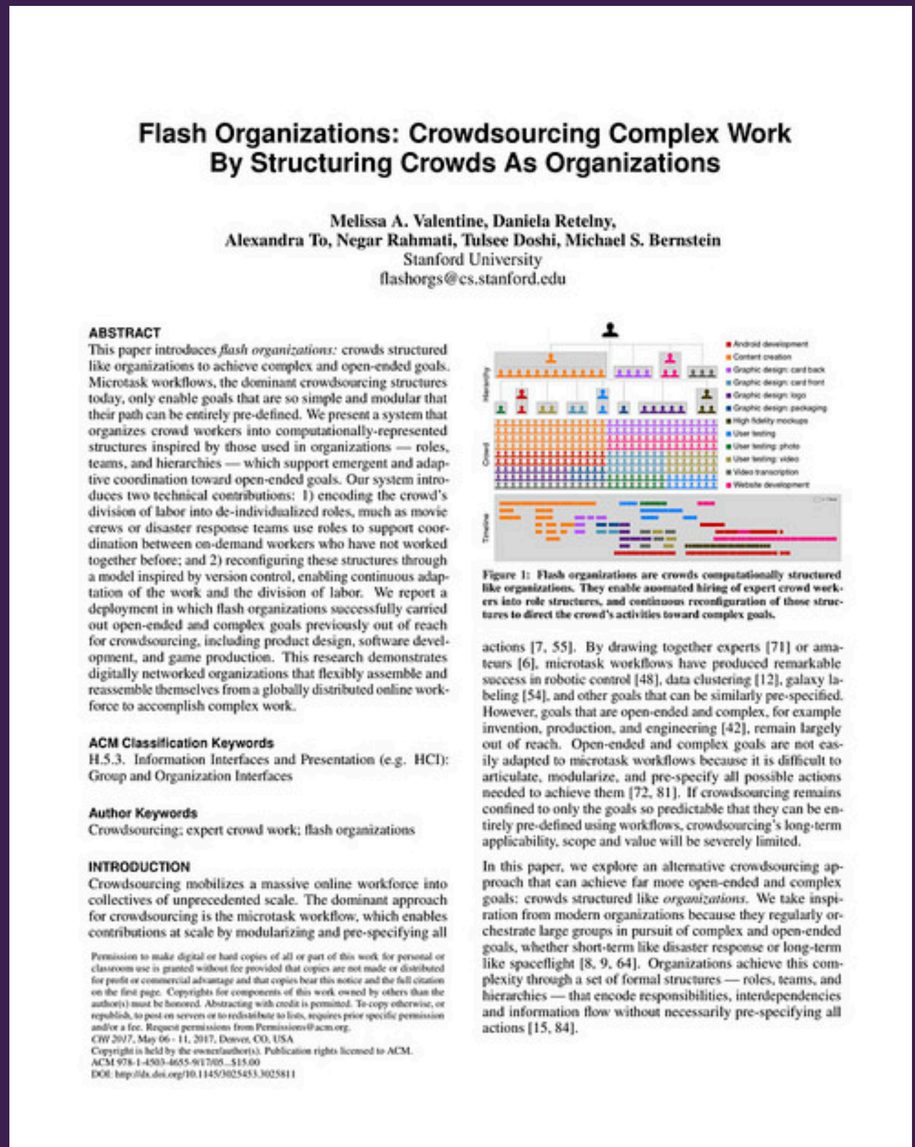
In this paper, we explore an alternative crowdsourcing approach that can achieve far more open-ended and complex goals: crowds structured like *organizations*. We take inspiration from modern organizations because they regularly orchestrate large groups in pursuit of complex and open-ended goals, whether short-term like disaster response or long-term like spaceflight [8, 9, 64]. Organizations achieve this complexity through a set of formal structures — roles, teams, and hierarchies — that encode responsibilities, interdependencies and information flow without necessarily pre-specifying all actions [15, 84].

Social debugging: flash organizations

We picked a small number of domains and *manually* generated quick test tasks for them. We posted these as jobs, giving a time limit. We *manually* evaluated the results.

We didn't care about generalizability or software integration.

Afterwards, we asked ourselves: could this scale to hundreds of people and tens of domains?



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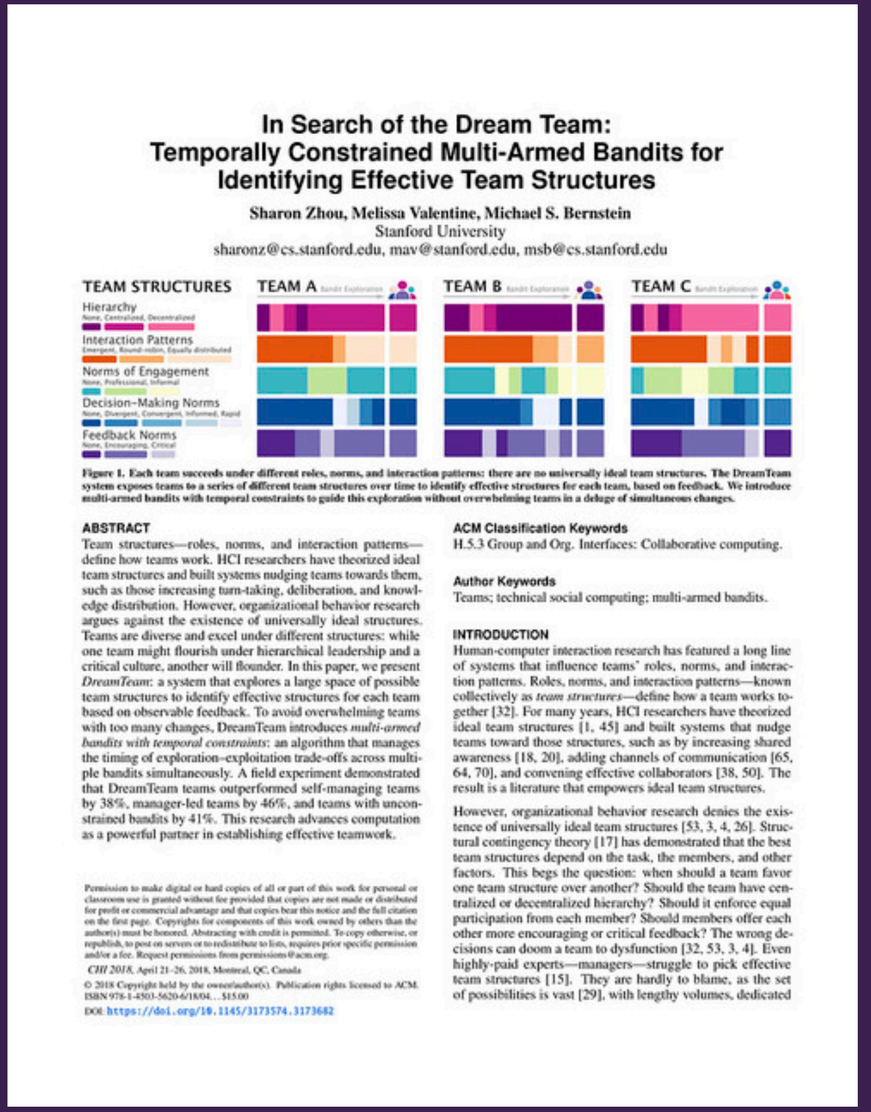
Engineering: Dream Team

Problem: This project used multi-armed bandits to identify over several rounds of interaction whether teams should be flat or hierarchical, supportive or critical, etc. But we didn't know: could these multi-armed bandits actually converge fast enough to be useful?

We had a rough implementation of the multi-armed bandits, but it wasn't production ready for interacting with teams.



In Search of the Dream Team: Temporally Constrained Multi-Armed Bandits for Identifying Effective Team Structures

Sharon Zhou, Melissa Valentine, Michael S. Bernstein
Stanford University
sharonz@cs.stanford.edu, mav@stanford.edu, msb@cs.stanford.edu

Figure 1. Each team succeeds under different roles, norms, and interaction patterns: there are no universally ideal team structures. The DreamTeam system exposes teams to a series of different team structures over time to identify effective structures for each team, based on feedback. We introduce multi-armed bandits with temporal constraints to guide this exploration without overwhelming teams in a deluge of simultaneous changes.

ABSTRACT
Team structures—roles, norms, and interaction patterns—define how teams work. HCI researchers have theorized ideal team structures and built systems nudging teams towards them, such as those increasing turn-taking, deliberation, and knowledge distribution. However, organizational behavior research argues against the existence of universally ideal structures. Teams are diverse and excel under different structures: while one team might flourish under hierarchical leadership and a critical culture, another will flounder. In this paper, we present *DreamTeam*: a system that explores a large space of possible team structures to identify effective structures for each team based on observable feedback. To avoid overwhelming teams with too many changes, DreamTeam introduces *multi-armed bandits with temporal constraints*: an algorithm that manages the timing of exploration–exploitation trade-offs across multiple bandits simultaneously. A field experiment demonstrated that DreamTeam teams outperformed self-managing teams by 38%, manager-led teams by 46%, and teams with unconstrained bandits by 41%. This research advances computation as a powerful partner in establishing effective teamwork.

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H.5.3 Group and Org. Interfaces: Collaborative computing.

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INTRODUCTION
Human-computer interaction research has featured a long line of systems that influence teams' roles, norms, and interaction patterns. Roles, norms, and interaction patterns—known collectively as *team structures*—define how a team works together [32]. For many years, HCI researchers have theorized ideal team structures [1, 45] and built systems that nudge teams toward those structures, such as by increasing shared awareness [18, 20], adding channels of communication [65, 64, 70], and convening effective collaborators [38, 50]. The result is a literature that empowers ideal team structures.

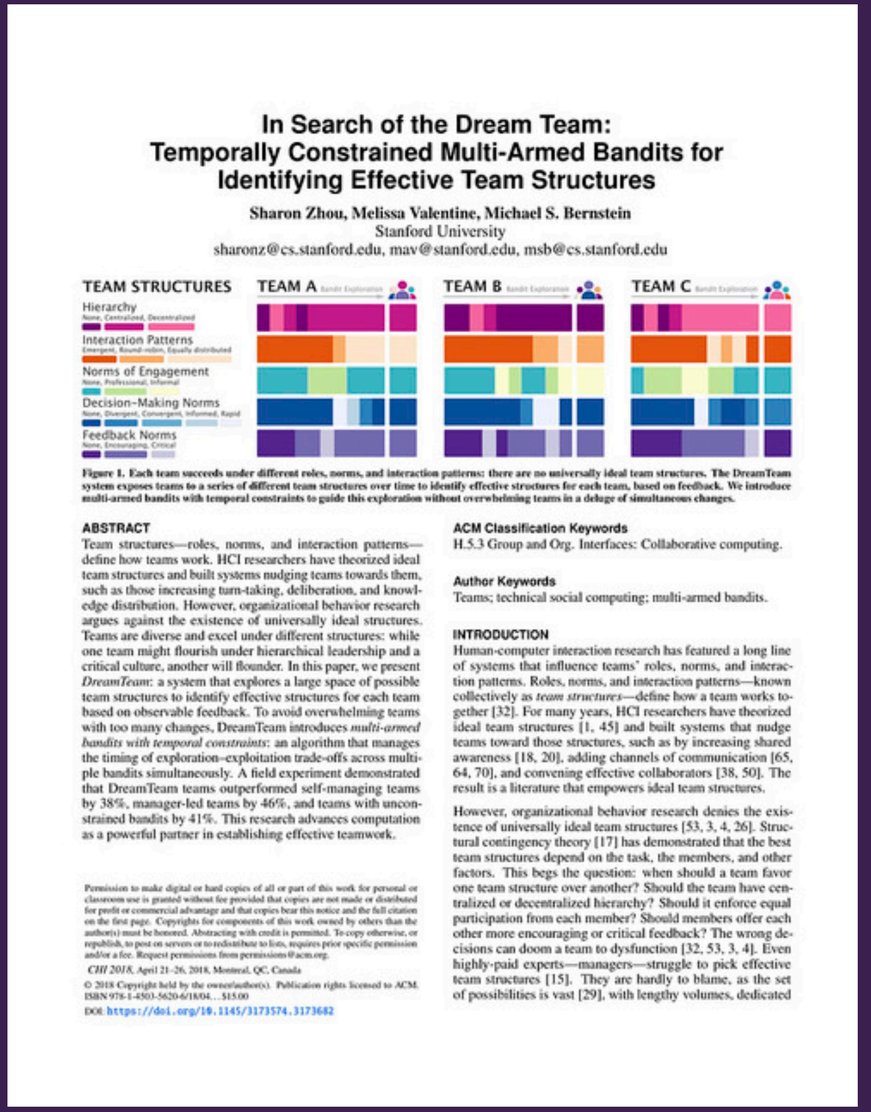
However, organizational behavior research denies the existence of universally ideal team structures [53, 3, 4, 26]. Structural contingency theory [17] has demonstrated that the best team structures depend on the task, the members, and other factors. This begs the question: when should a team favor one team structure over another? Should the team have centralized or decentralized hierarchy? Should it enforce equal participation from each member? Should members offer each other more encouraging or critical feedback? The wrong decisions can doom a team to dysfunction [32, 53, 3, 4]. Even highly-paid experts—managers—struggle to pick effective team structures [15]. They are hardly to blame, as the set of possibilities is vast [29], with lengthy volumes, dedicated

Engineering: Dream Team

We used a *rough simulation*! Assuming some roughly accurate numbers in how much each team benefited from each bandit setting, we generated teams and simulated the bandits over a few rounds.

The answer: they converged quickly enough that this might work!

(The next step: wizard of oz the interface, so we could test it "for real" without building integrating software.)



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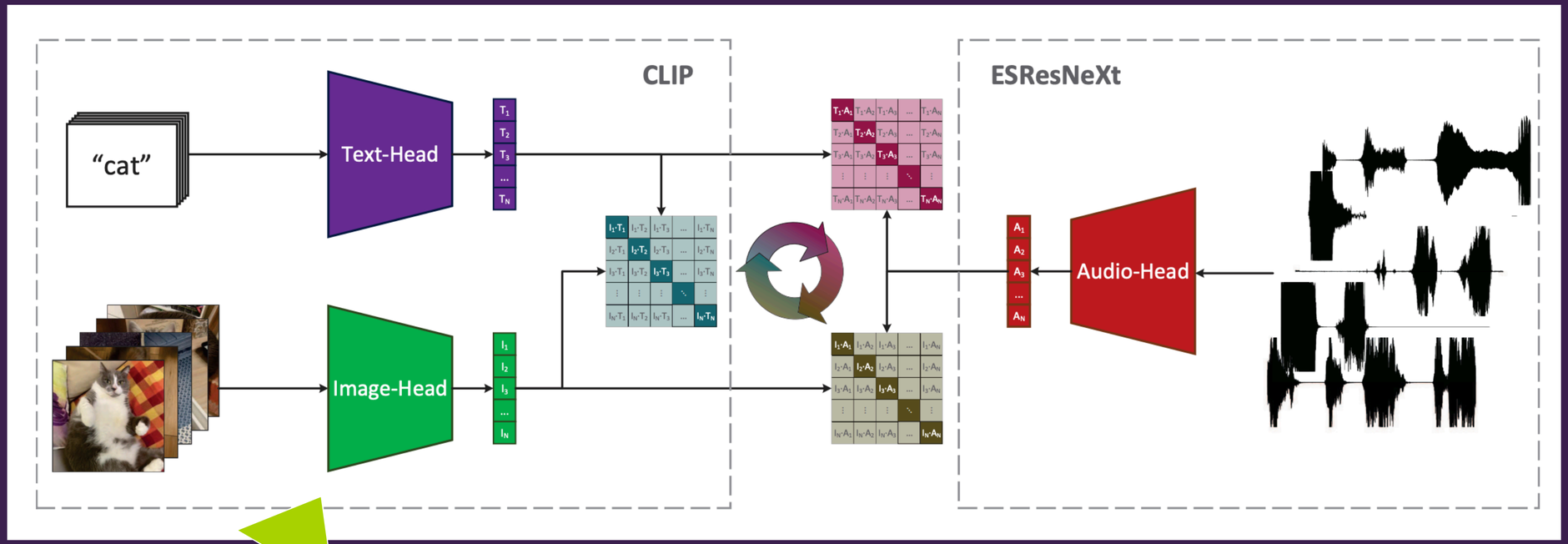
Use an easy or smaller subset of the data, make simplifying assumptions while working on your proof, ignore other nagging questions for the moment

Research Engineering: Do minimal engineering to answer your question (vector)

Find simple workarounds if original plan is taking long, mock in data

Example: ML Experiment

AudioCLIP

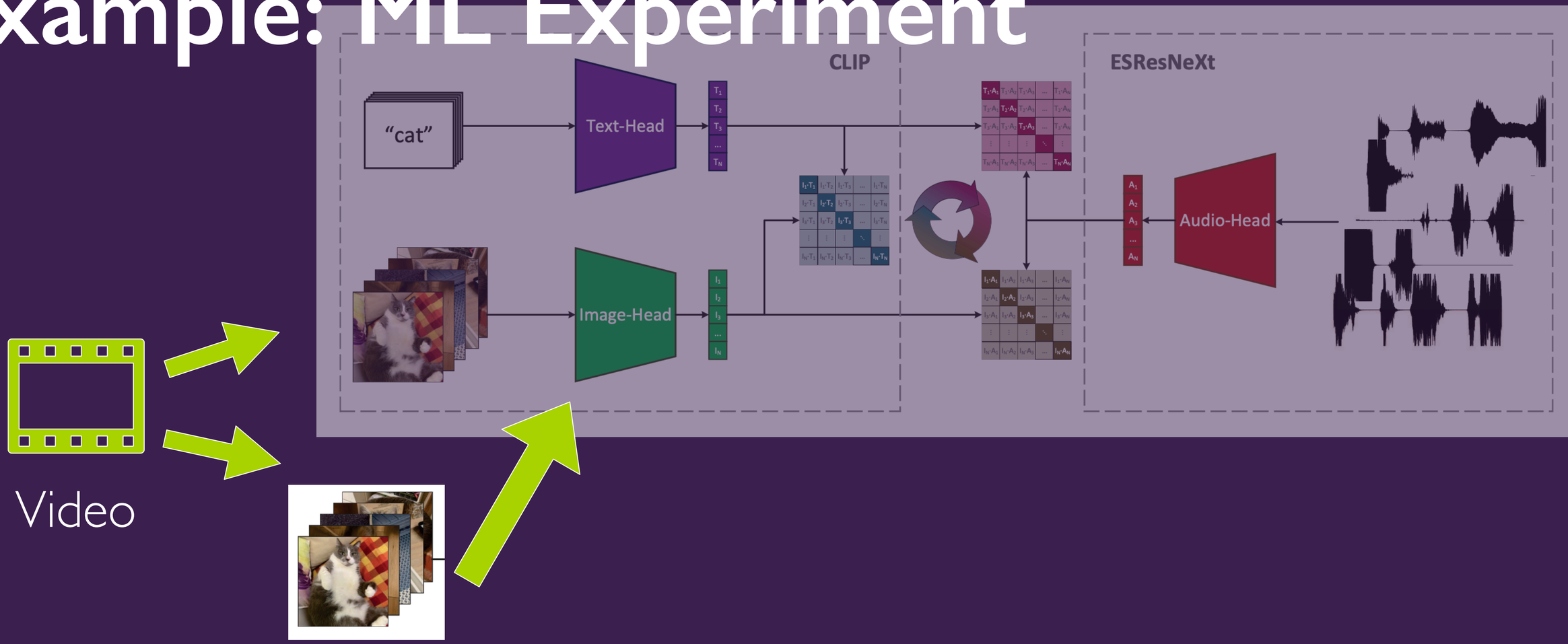


Video

Research question: Will this improve embeddings?

Guzhov et al. 2021. "AudioClip: Extending CLIP to Image, Text and Audio"

Example: ML Experiment



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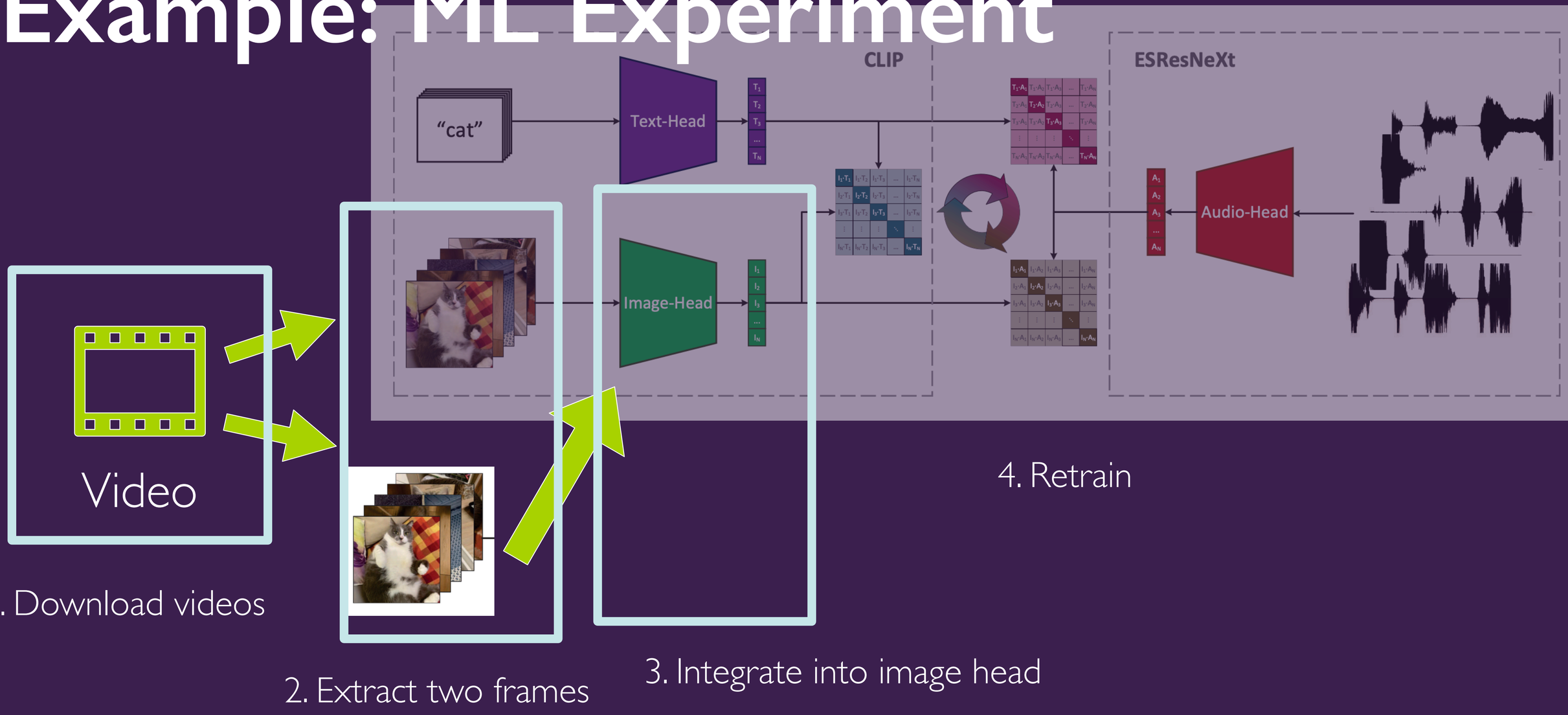

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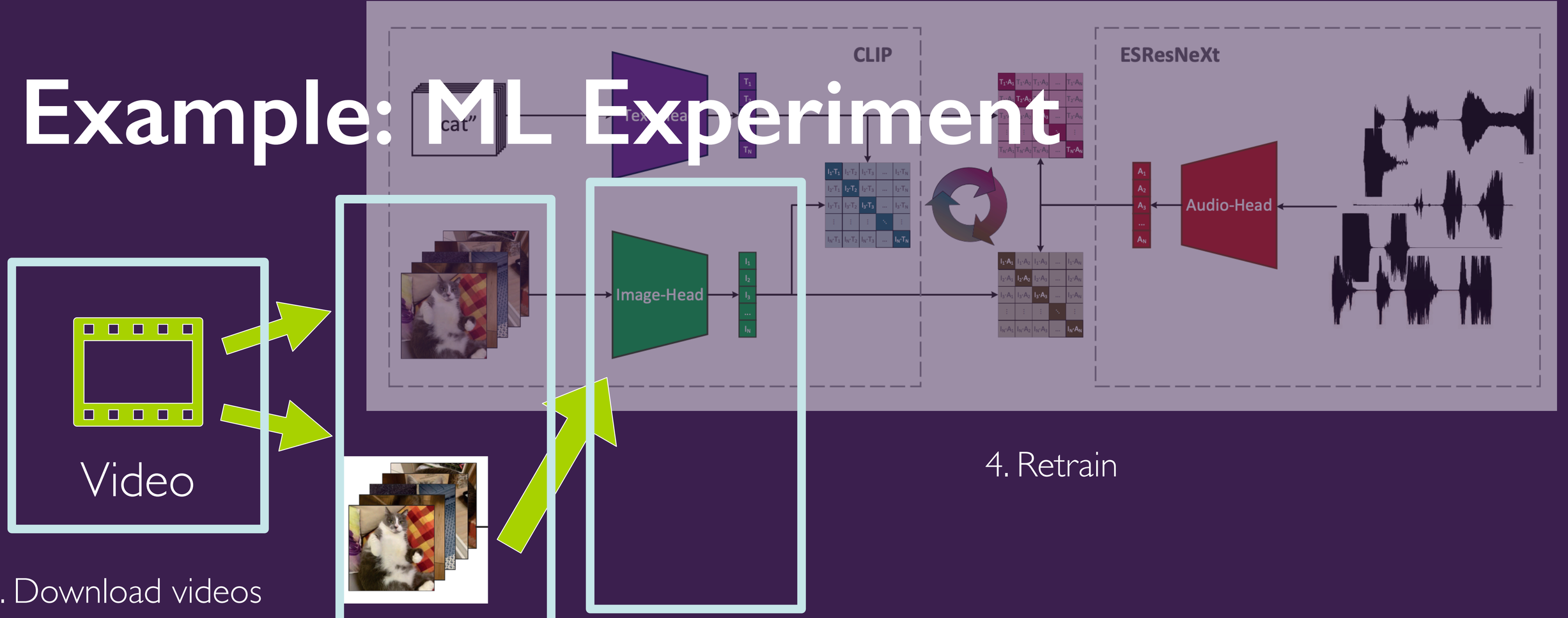


1. Download videos

2. Extract two frames

3. Integrate into image head

4. Retrain

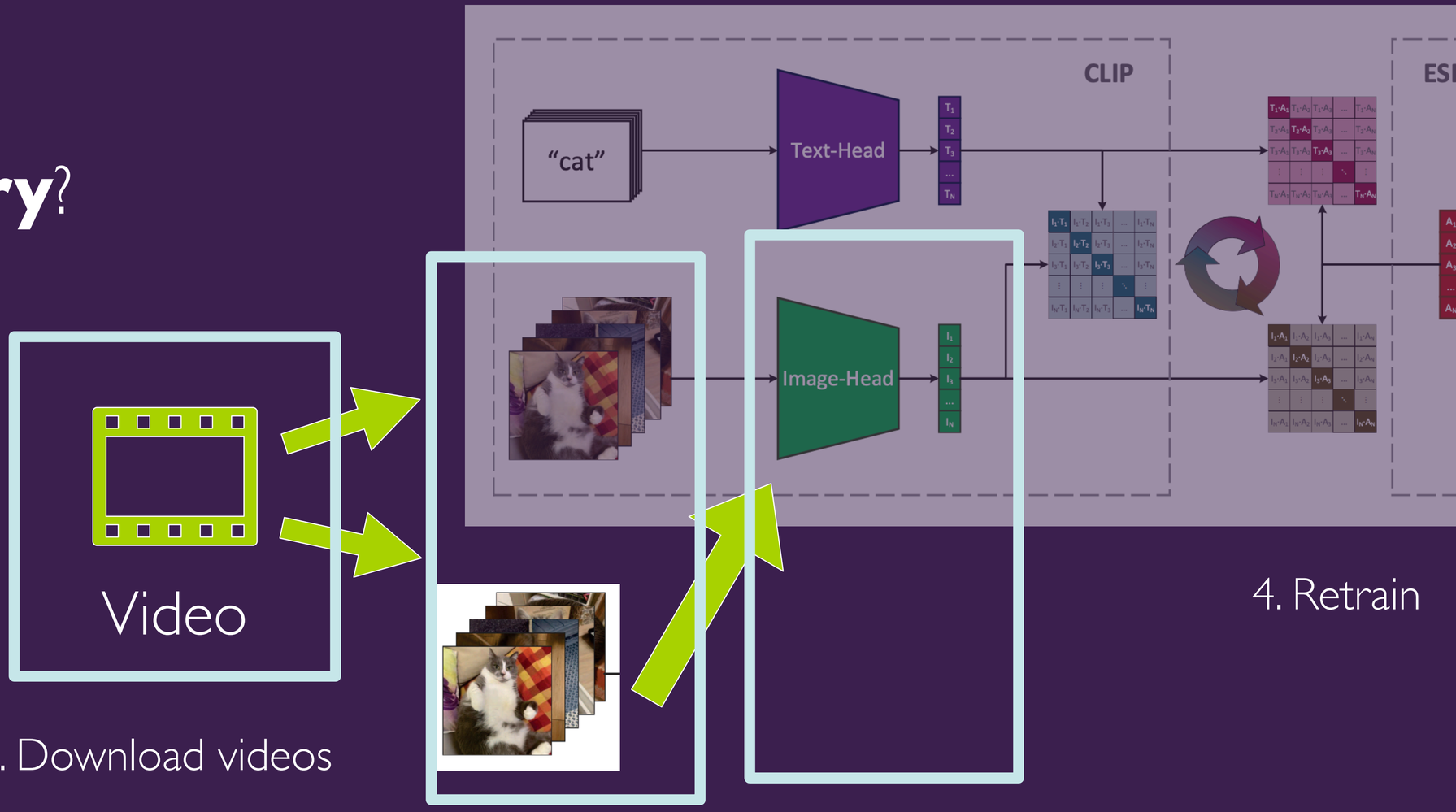
Problem:
2 weeks later,
still on step 1

Guzhov et al. 2021. “AudioClip: Extending CLIP to Image, Text and Audio”

Example: ML Experiment

What is **core**?

What is **periphery**?



Velocity: Research Engineering

Core: modify model to take in two images during training

Periphery: everything else

It's easy to get distracted….

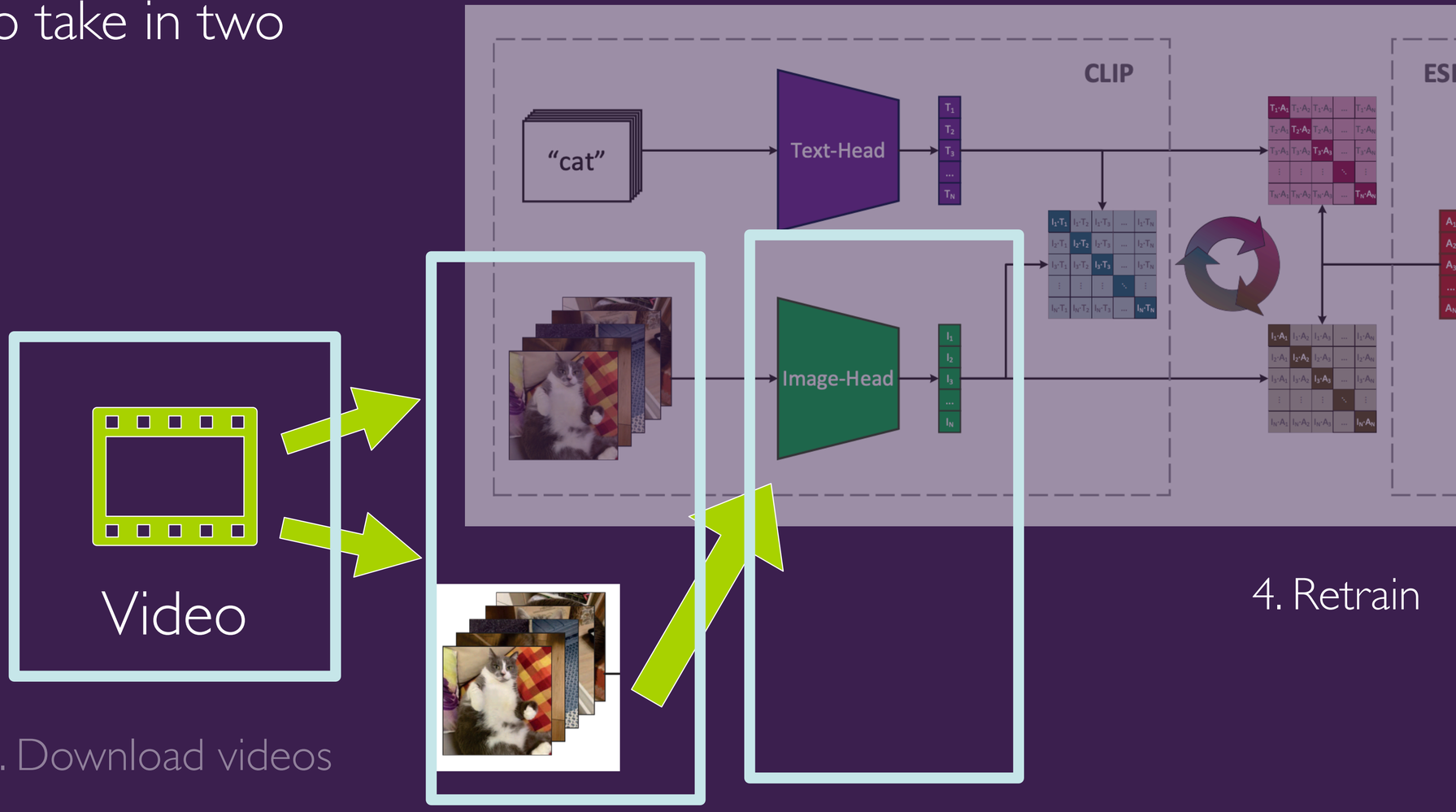
Remember: your goal is **not** to build a perfect, robust system. That's the job of engineers, not researchers.

Your goal is to get a prototype working to answer your question!

Velocity: simplify ruthlessly

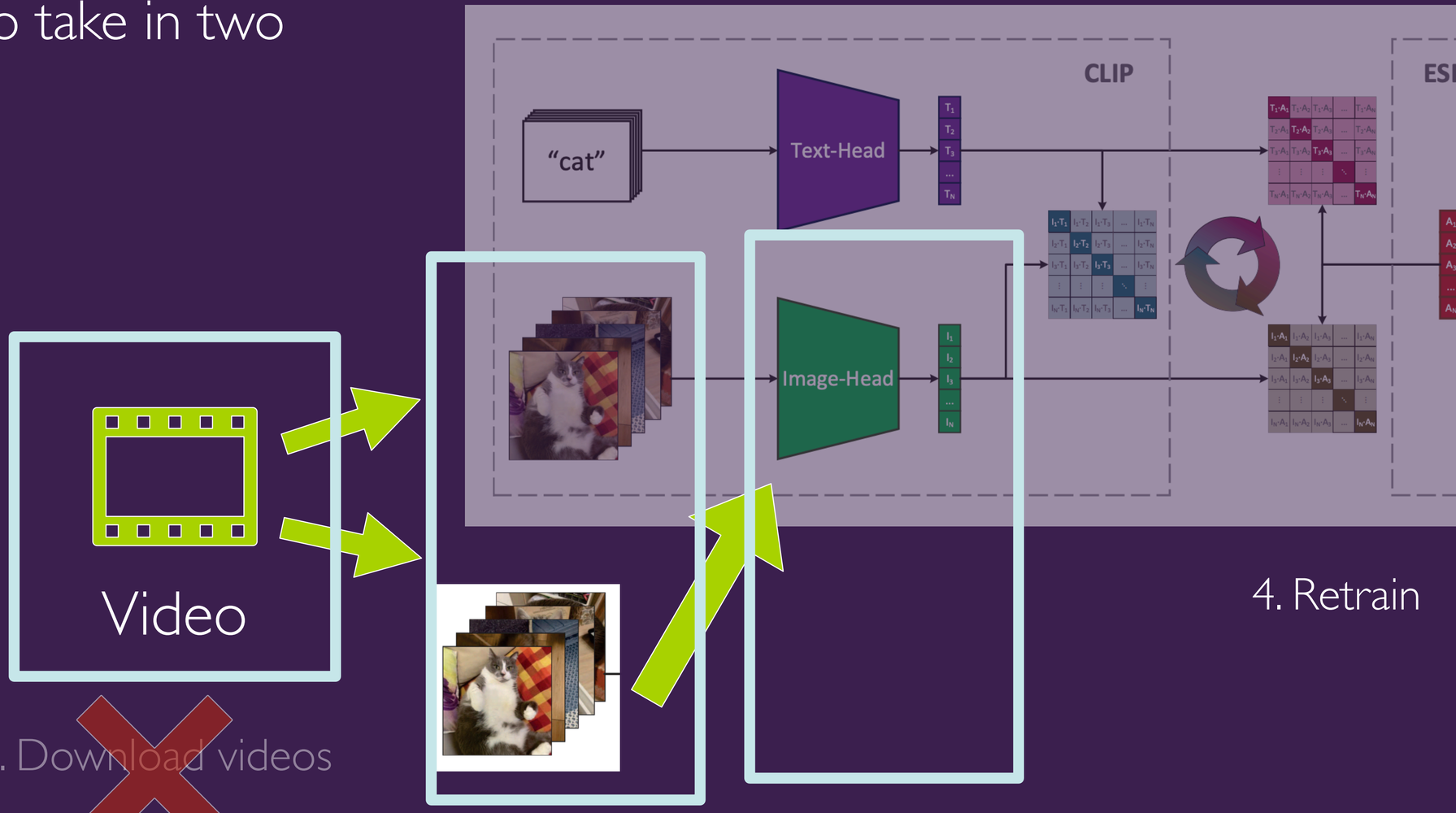
Example: ML Experiment

Priority: modify model to take in two images during training



Example: ML Experiment

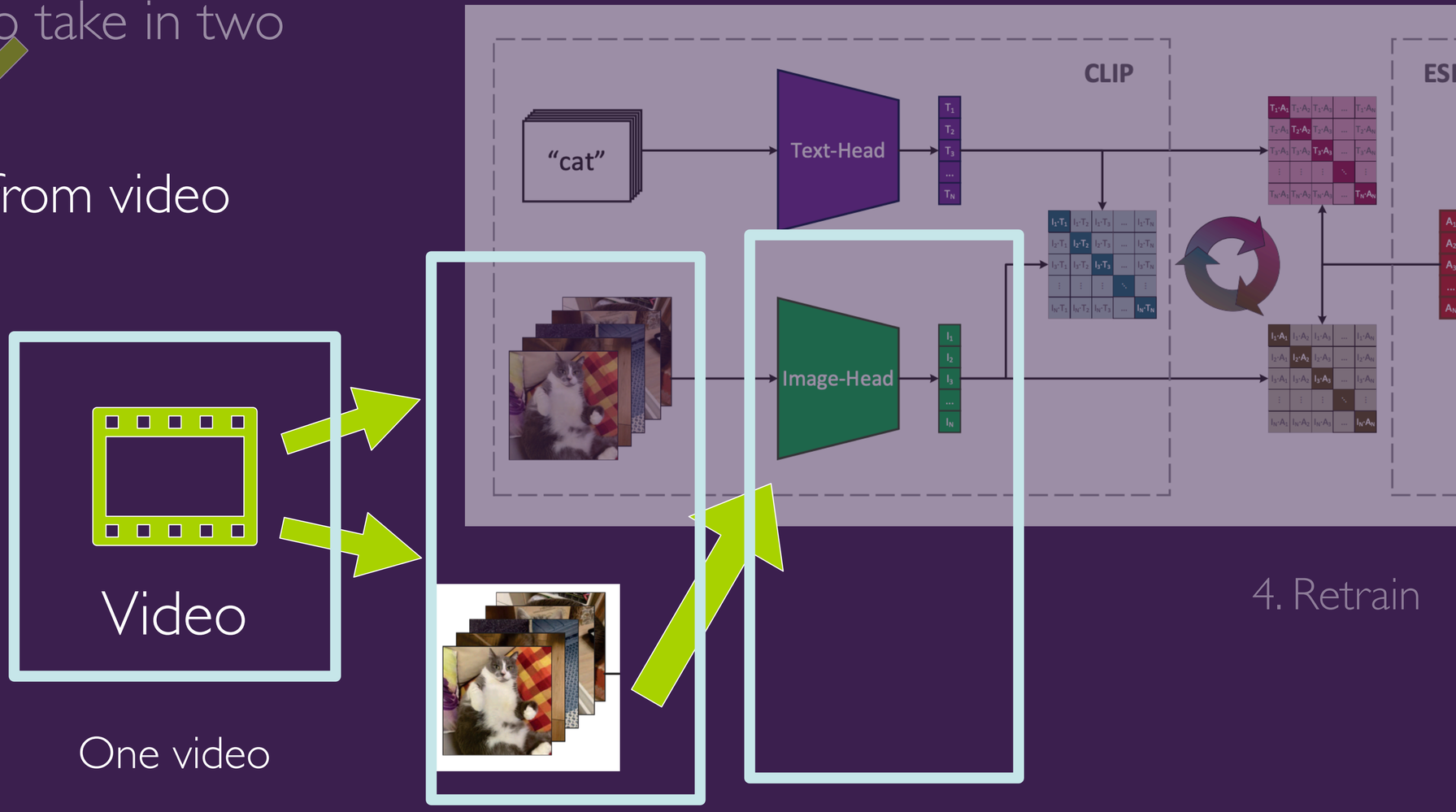
Priority: modify model to take in two images during training



Example: ML Experiment

Priority: modify model to take in two images during training ✓

Next priority: Two frames from video

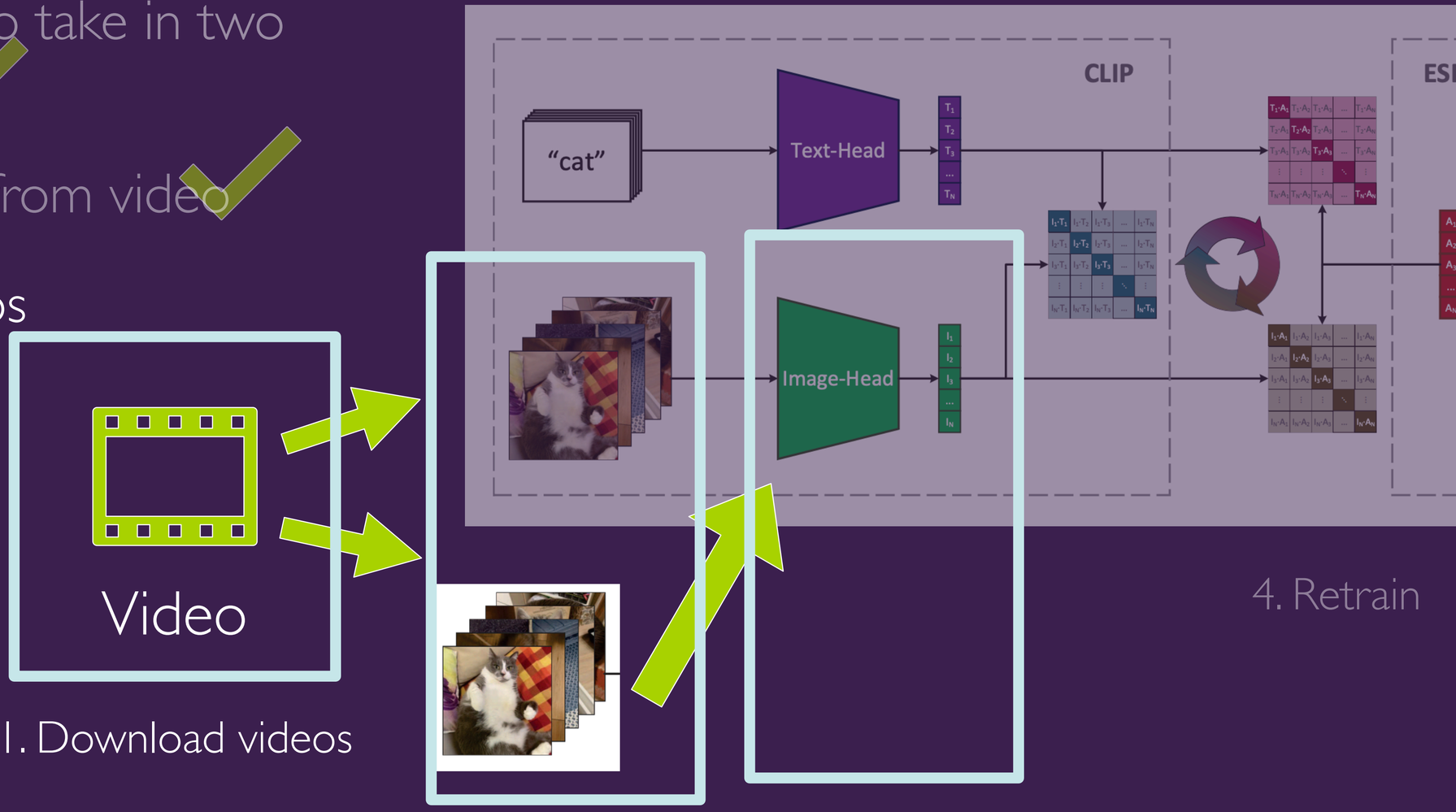


Example: ML Experiment

Priority: modify model to take in two images during training ✓

Next priority: Two frames from video ✓

Next priority: Scrape videos



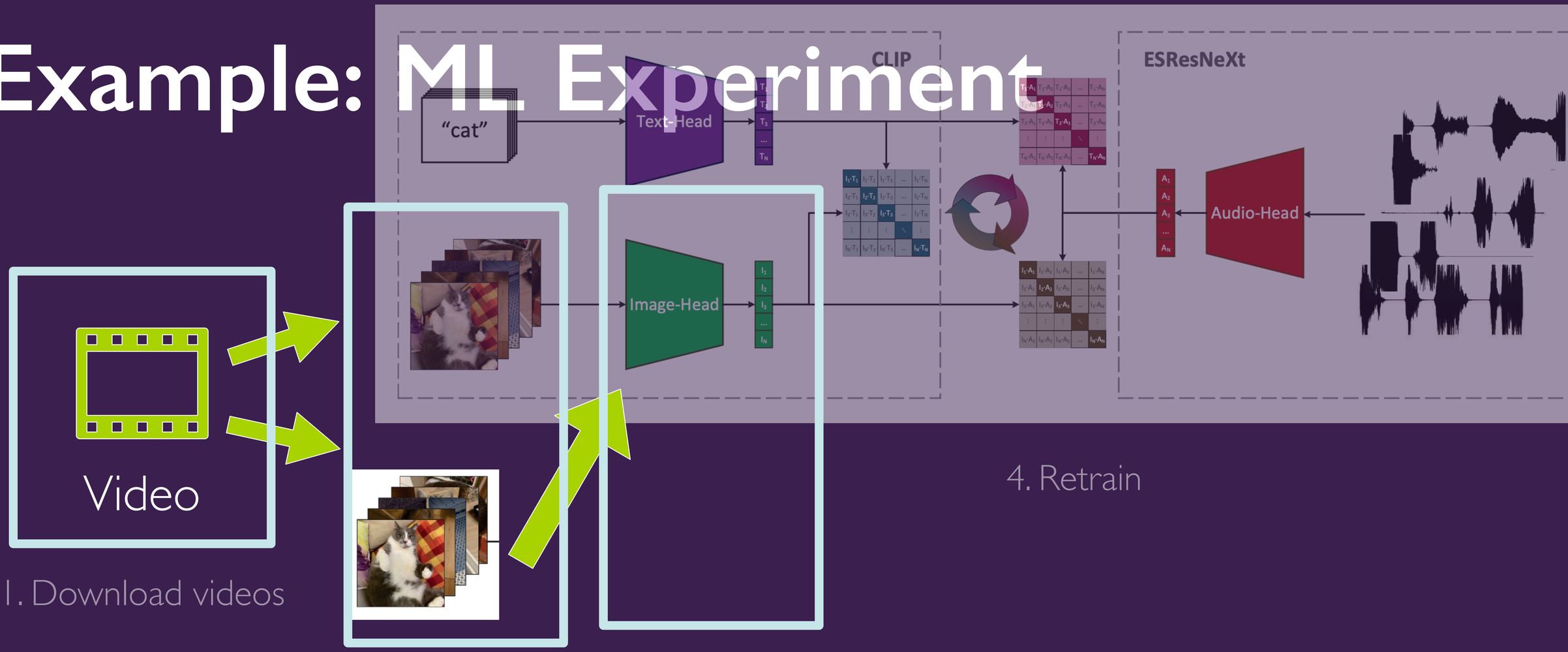
1. Download videos

2. Two frames from a video

3. Integrate into image head

4. Retrain

Example: ML Experiment



Can parallelize each stage among team members
Use mock data so no one has to wait

Core-periphery mindset

Answer questions, don't engineer. This tends to rankle essentially every facet of your undergraduate training.

Too often, people pursue perfection in the first pass: perfect drafts, perfectly engineered software, perfect interaction design.

Remember: the goal is to answer the question, not to build that part of your system permanently (yet).

All together now

Each week, we engage in vectoring to identify the biggest unanswered question. This should be the focus of your velocity sprint for the week.

To hit high velocity, be strategic about stripping out all other dependencies, faking what you need to, etc., in order to answer the question.

Be prepared to iterate multiple times within the week!

Your turn

Pair up with someone not on your project.

5min each person: describe your project's current state, the current question you're trying answer. Brainstorm together how to increase velocity.

Afterwards, we'll share out.

A reminder: the algorithm

1. Articulate the question you're answering.
2. Decide what's absolutely core to answering that question.
3. Decide what's peripheral.
4. Decide the level of fidelity that is absolutely necessary.
5. Go — but be open to reevaluating your assumptions as you go.
6. Loop with a new question.

Tips and tricks

“I’m being low velocity.”

Velocity = distance / time

So, if your velocity is low, you have two options:

1. **Cover more distance**: habits that can get you further in the same time (e.g., “try harder”, “be a better engineer”)

You’re typically already maxed out on this.

2. **Decrease the time**: prototype more effectively

WIN. Prototype more narrowly, lower your fidelity expectations (e.g., spit out any draft)

Checking email or InstaSnapFace?

This signals a lack of focus, and is a pretty certain predictor that you're in a swamp.

It means you're prototyping too broadly: **you're unfocused! focus your goal.** Or you're requiring too high a level of fidelity: **you have unreasonable standards! lower your expectations**.

Develop an internal velocity sensor, and as soon as you recognize this, apply one of the two rules.

Lowering standards: parallelism

Too often, we suffer from what's known in the literature as **fixation**: being certain in an idea and pursuing it to the exclusion of all else. We cannot separate ego from artifact.

Instead, to answer the question, it's often best to **explore multiple approaches in parallel**.

> "While the quantity group was busily churning out piles of work—and learning from their mistakes—the quality group had sat theorizing about perfection, and in the end had little more to show for their efforts than grandiose theories and a pile of dead clay."
> — Bayles and Orland, 2001

Corollary 1: pivoting

Velocity is why cutting yourself off short and pivoting to a new project can be so dangerous in research.

> Typically people pivot after a week in the swamp (the "fatal flaw fallacy"), rather than iterating with high velocity out of the swamp.

I promise that the project you pivot to will have a swamp too. Learn to increase velocity and prototype your way out of the swamp faster, instead of seeking out a swampless project.

Corollary 2: technical debt

Obviously, at some point you need to make sure you're not too deep in technical debt, design debt, or writing debt.

But luckily, **most people can only run their processors hot for a few hours a day**. Everything I've described takes a lot out of you.

When you're out of creative cycles, spend time maturing other parts of your project that are no longer open questions. Or, sometimes we reach a phase where we pause prototyping and focus on refinement and execution for a bit.

Why is velocity so important?

Great research requires high velocity

Don't let 6-12 month paper deadlines obscure the velocity at which research needs to move in order to succeed.

If you want to achieve a high impact idea, you need to try a lot of approaches and refine and fail a lot. You want to do that as quickly as possible.

If you can prototype and learn and fail 5x as quickly as the next person, you will be able to achieve far more risky and impactful research.

Takeaways, in brief

1) The swamp is real, and it slows visible progress.

2) Velocity is a far better measure of yourself than progress, and it’s something you actually have control over.

3) Achieve high velocity by being clear what question you're answering, and focusing ruthlessly on the core of that question while stripping out the periphery.

4) If you're low velocity, velocity = distance / time. Either increase distance (rarely possible) or decrease time (often possible: you're too broad or too perfectionist).

And finally…

Get into your project groups and discuss your strategy for velocity. What's working? What can be improved?

197

Due **next** Thurs 5/11: Progress Report III

- This week's vector
  - What is core and periphery?
- This week's plan
- This week's result
- Next week's vector
- Next week's plan

197C

Next Thurs 5/11: no written assignment due

Work towards your research milestone!

Reminder:

Submit your attendance on Canvas!

Velocity in Research