‘25 iHARP REU research plan

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ABSTRACT: This undergraduate research project, conducted as part of the iHARP REU program, explores user interface design strategies to support polar scientists working with automated methods for analyzing environmental change. As research in polar regions increasingly involves large-scale satellite imagery, simulation data, and machine learning techniques, there is a growing need for tools that help scientists effectively visualize and interpret the outputs of these automated systems. This project focuses on developing interface features that align with scientific reasoning practices, supporting exploration, comparison, and iterative hypothesis development. As a case study, the project investigates glacier calving events using automated image segmentation of satellite data. The student will prototype interface elements that allow users to visualize and examine computer vision outputs and metrics, and spatial and temporal patterns. By designing and testing interfaces that facilitate understanding of calving dynamics and their contributing factors, the project aims to enhance the usability of AI-assisted workflows in polar science. Through interviews with polar researchers, iterative interface design, and interactive data visualization, the project aims to contribute to broader efforts to create transparent and collaborative AI systems in environmental science, and to develop visual interactive tools that strengthen quantitative evaluation methods.

# How to Approach Your Research Project

The core of doing research—especially at this undergraduate level—is learning how to independently approach complex, open-ended questions. This summer is about building your capability as a self-directed problem solver, guided by your own curiosity, questions, and observations.

**The Research Mindset**

* **Start with Curiosity:** Your questions are the foundation of your project. Always start by clearly formulating what you want to know or what doesn't yet make sense to you. Keep a running list of questions and continually revisit and refine them.
* **Research is an active, iterative process.** Rather than immediately asking for solutions, use available resources first:
  + **Read documentation and online resources,** tutorials, guides, or relevant forums.
  + **Always explore literature and examples.** Explore how others have approached similar problems. Understanding the approaches of others is key to forming your own insights.
  + **Use trial and error.** Experiment with your ideas. Research involves actively testing hypotheses, iterating based on what you discover.
* **Our goal is to develop Independence.** While you have support, your goal is to become self-sufficient. Use discussions with your mentors (Rohan, myself, other faculty) not simply to ask for solutions, but to clarify your understanding, challenge your assumptions, or get unstuck after thorough attempts to resolve your question on your own.
* **Documentation and Reflection are paramount to developing your skills as a computer scientist/developer.**  Keep consistent notes, but in your own words. Document your thought process, why you made certain decisions, what worked, what didn’t, and why.

In short, research isn’t about knowing everything upfront—it's about being curious, resourceful, reflective, and independent. Embrace the process of exploring, learning, and refining your understanding as you build something meaningful this summer.

**Clarifying Understanding and Asking Questions**

An important skill in research (and a critical professional habit) is to speak up when something isn't clear. **Never assume you're supposed to already know everything someone mentions**, especially if they're using unfamiliar words or jargon. It’s completely normal (and encouraged!) to ask for clarification.

* **Interrupt Kindly:** When someone (even a professor or experienced researcher) uses terms or ideas you don't fully understand, politely but firmly interrupt to ask for clarification. For example:  
   *"I'm sorry to interrupt, but could you quickly explain what you mean by X?"* or  
   *"Could we pause for a moment? I'm not familiar with that term—could you briefly clarify it?"*
* **Advocate for your own learning.** The goal is to fully understand and internalize concepts rather than to appear knowledgeable. This practice will help you build genuine expertise and confidence.
* **Clarifying questions are valued.**  Asking thoughtful questions demonstrates maturity and genuine engagement. Remember, experienced researchers appreciate curiosity and authenticity, not quiet agreement.

This habit will significantly enhance your learning experience and strengthen your capacity as an independent researcher and professional.

**How to Use Shared Papers and Resources**

Throughout the summer, I may share research papers, articles, or resources with you. **It’s important to understand that these are meant as inspiration, not necessarily as templates to replicate exactly.**

* **Look for ideas, not instructions.** Focus specifically on how authors present, communicate, and visualize their findings, rather than getting overwhelmed by the details of methods, complex machine learning techniques, or technical implementations.
* **Abstract the problem** by practicing identifying the core principles and concepts from these resources. Ask yourself:
  + “What interesting visualization techniques did the authors use?”
  + “How do they clearly communicate complex information?”
  + “Could similar visualization ideas help in our specific scenario with glacier calving?”
* **Avoid unnecessary complexity.** Do not feel obligated to replicate complex machine learning or analytical methods from these papers. The key is to adapt useful visual and conceptual strategies to your specific research questions and datasets.

# Expectations on the Use of AI/ChatGPT

Throughout the research experience, you are encouraged to leverage AI tools like ChatGPT responsibly and strategically. These tools can be helpful for clarifying concepts, debugging code, and exploring new topics or methods. However, your ultimate goal is to deeply understand and be able to clearly explain all parts of your project, especially your code, design choices, and analyses, without assistance from AI.

This expectation reflects real-world professional scenarios, particularly in job interviews and collaborative environments, where employers and colleagues will expect you to demonstrate your own understanding and ability to communicate your work clearly and independently.

Therefore, please:

* Use AI tools for conceptual support or clarification when necessary.
* Avoid relying on AI tools for note-taking or as a replacement for actively engaging with research literature or your own thought process.
* Ensure you fully comprehend the logic, structure, and details of your code and analyses so that you can confidently explain your work independently.

The intention here is to encourage genuine learning, curiosity-driven inquiry, and confidence in your own expertise.

It's crucial that you keep track of **provenance**: where you found ideas, data, code snippets, examples, visualizations, or any other resources you use. Always save direct links and references so you can accurately attribute your sources later. Maintaining clear provenance not only enhances your credibility and professional rigor but also allows you (or others) to revisit and verify sources in the future, making your research process more transparent, reproducible, and reliable.

# Suggested Tools

* **Learning and knowledge checks**: DataCamp
* **Visualization & Analysis**: Jupyter, Pandas, GeoPandas, matplotlib, Streamlit, Plotly, [Panel](https://panel.holoviz.org/) with Holoviz and Bokeh
* **UI Design & Prototyping:** Hand sketching, Figma, Adobe XD, Miro
* **Documentation & Note-taking:** Notion, Obsidian, Roam Research, GitHub (code & version control), [slides.com](http://slides.com)
* Website: Streamlit, [gradio](https://www.gradio.app/), others

# Data

https://usicecenter.gov/Products/AntarcIcebergs

# Slides, Background Reading for Context, Examples to Pique your Curiosity

* <https://slides.com/rebeccawilliams-3/iharp-research-intro/fullscreen>
* <https://www.antarcticglaciers.org/glaciers-and-climate/observing-and-monitoring-glaciers-and-ice-sheets/observing-glacier-change-space/>
* <https://examples.holoviz.org/gallery/datashader_dashboard/datashader_dashboard.html>
* <https://its-live.jpl.nasa.gov/>

# Rough Schedule

**Week 1: Orientation and Introduction**

Goals:

* Introduction to the research context: AI, UI design, polar science, glacier calving.
* Gain an initial understanding of what we mean by “research”: structured curiosity, iterative research, documentation, note-taking. It is NOT just software development.
* Do DataCamp Modules in visualization concepts and interactive vis.

Activities:

* What constitutes research: inquiry-driven, iterative, open-ended questions. Practice some effective research techniques: structured curiosity, systematic note-taking (use google docs or similar)
* Basic reading about polar research, glacier calving, icebergs satellite imagery, and automated segmentation/tracking techniques.
* Setup computational environment (Python, Jupyter, basic libraries: matplotlib, pandas, geopandas, possibly Streamlit or Plotly for visualization prototypes).

**Week 2: Dataset Exploration and Defining Research Questions**

Goals:

* Select and explore datasets - check with Rohan for this
* Define initial research questions on visualizing AI/CV/ML outputs.

Activities:

* Dataset selection: Explore available datasets
* Everything you do should be based on a question you have. Formulate initial exploratory questions, for example:
  + How do calving event detections vary spatially and temporally?
  + How do quantitative metrics correlate to qualitative overlays?
  + How can AI segmentation/tracking results be effectively visualized and interrogated?
* Document data sources, metadata, and initial exploratory analyses (tools: Jupyter notebook for initial exploration).

**Week 3: Interface Design Fundamentals and Initial Prototyping**

Goals:

* Explore UI design fundamentals specifically for scientific workflows. Check on DataCamp and other resources for this
* Sketch preliminary UI ideas and interface features.

Activities:

* Search for related works and discussion on scientific visualization, human-computer interaction (HCI) basics.
* Informal interview/conversation with at least 3 scientists
* Sketch initial interface ideas
* Develop initial exploratory visualizations

**Week 4–6: Iterative Prototype Development**

Goals:

* Develop initial interactive prototypes of visualization tools.
* Iterate based on weekly feedback and user-oriented questions, interviews/feedback from researchers.

Activities (iterate):

* Refine visualization prototype, considering ways scientists might interpret and interact with segmentation or tracking results.
* Iterate on visual interfaces to clearly show segmentation/tracking accuracy, temporal/spatial patterns, and uncertainty.
* Conduct semi-structured interviews with 1-3 polar scientists, documenting feedback rigorously
* Reflect on feedback, document insights, and revise research and design questions accordingly

**Week 7: Synthesis, Documentation, and Presentation Prep**

Goals:

* Consolidate insights and finalize prototype visuals.
* Start drafting research document and presentation materials.

Activities:

* Organize findings into clear research narrative: context, approach, prototype development, insights, and limitations.
* Draft short research document summarizing project background, methods, findings, and lessons learned.
* Develop slide deck clearly presenting the project's motivation, interface design, iterative development, and key insights.

**Week 8: Finalization, Presentation, and Reflection**

Goals:

* Finalize written document and slide deck.
* Deliver final presentation to peers/faculty.
* Reflect on research experience and growth.

Activities:

* Final revisions and polishing of research document and slide deck.
* Practice and deliver final presentation summarizing summer experience and key insights.
* Reflective writing on learning experience, skills developed, and future interests.

# Additional Resources and Info

* <https://panel.holoviz.org/reference/panes/DeckGL.html>
* <https://www.zippia.com/research/education-roi/>
* <https://pair.withgoogle.com/explorables/uncertainty-calibration/>