# let's talk research.

Everything starts from here



# What is research?

Research is a specialized study of some topic of interest to understand, explore and contribute to the community.

If you are **curious** about something, do research about it!

- Industrial R&D
- Academic Applied & Theoretical
- Institutions & Organisations
- Or just at some personal level
  - Even Googling about something out of curiosity is research



Do you want to work on the **next big thing?**  Conferences -**Fully-funded** Exotic Vacay

# But why research?

Forget about 9 to 5, Flexible Schedule!!! You choose yourown weekends





# FOW to START?

# You need to find something that excites you! • Viewing University & Labwebsites

**Carnegie Mellon University** The Robotics Institute

Research

The Robotics Institute is a worldwide hub of robotics research that encompasses a diverse array of topics.

#### **BROWSE FACULTY AND RESEARCH TOPICS**

Field & Service Robotics Graphics & Creative Tools Human-Centered Robotics Manipulation & Interfaces Robot Structures



Filter Research Topics

Robotics Foundations Sensing & Perception

# How to START?

# • Public Lectures / YouTube Videos







#### MIT 6.S191: Introduction to Deep Learning

Alexander Amini · Updated yesterday

MIT Introduction to Deep Learning | 6.S191 • 49:01 MIT 6.S191: Recurrent Neural Networks and Transformers • 58:18

VIEW FULL PLAYLIST

### RI Seminar: Andrew E. Johnson : The Search for Ancient Life on Mars Began with a Safe Landing

1.1K views • 7 months ago



September 10, 2021 Andrew E. Johnson Principal Robotics Systems Engineer NASA Jet Propulsion Laboratory, California ...

#### RI Seminar: Matthew Johnson-Roberson : Lessons from the Field

1K views • 2 months ago



Matthew Johnson-Roberson Professor / Director of RI Robotics Institute, Carnegie Mellon University February 4, 2022 Lessons ...

# HOW to START?

## Read books



Matthew D. Schwartz



Richard Hartley and Andrew Zisserman

**WILEY-VCH** 

TEXTBOOK PHYSICS

Introduction to

**Elementary Particles** 

David Griffiths



VISION

MODELS, LEARNING, AND INFERENCE

DEEP LEARNING

and Aaron Courville

# HOW to START?

- You need to find something that excites you!
- Viewing University & Lab websites
- Public Lectures / YouTube Videos
- Read books
- Takto people / Don't be afraid to
  - reach out
- connect with someone
- DO NOT hesitate or be afraid to • Keep Hustling FTW!

# **CSRankings: Computer Science Rankings**

CSRankings is a metrics-based ranking of top computer science institutions around the world. Click on a triangle (>) to expand areas or institutions. Click on a name to go to a faculty member's home page. Click on a chart icon (the III after a name or institution) to see the distribution of their publication areas as a bar chart ~ . Click on a Google Scholar icon (1) to see publications, and click on the DBLP logo (1) to go to a DBLP entry. Applying to grad school? Read this first. Do you find CSrankings useful? Sponsor CSrankings on GitHub.



Google Search /YTVideos / **Conference Keynote** Speakers

notion)

	Count F	Count Faculty	
Aellon University 🔤 📠	19.1	161	
nois at Urbana-Champaign 画 📠	13.4	109	
setts Institute of Technology 📟 📠	12.2	89	

# **Field-specific** specialized rankings (for an initial

# How to bag **Opportunities?**



01 your area of interest

#### Search for them on different platforms 02

- Cold Emailing
- 03 profile
- 04

# Find people who have experience in

• LinkedIn - imp for AI/ML/Robotics • Academic Twitter - imp for AI/ML/Robotics

### Make a website for yourself / LinkedIn

### Academic CV (Overleaf) - Eg: https://nikv9.github.io/data/Nikhil\_CV.pdf

# How to co c mai?

- Short, Concise and Personalized is the Mantra!
- Greeting: **Respect** their expertise
- Intro: My name is NAME. I am a POSITION from AFFILIATION. I am writing to WHAT DO YOU WANT
- Context: Provide **SPECIFIC context**. Do yourhomework!
- Call for action: What do you expect from the recipient (short meeting, colab, ...)
- **Consistent format**: Never have inconsistent font type/sizes!!!
- Make sure that your full name "in English" appears as the sender
- Make it clear and structured: bold/italic fonts, bullet points easier to read
- Quality: Revise the emails before you send them. No Typos/Errors!!!



# How to read a paper?

- Don't tackle the paper as a whole
- Start with the easy things
  - Abstract, Intro, Figures, Tables
- The **three pass** technique
  - First pass the general idea
  - Second pass grasp the content
  - Third pass in-depth understanding

http://ccr.sigcomm.org/online/files/p83-keshavA.pdf



# FAQ

- What is the right time to decide between going into research or SDE role?
- Is a **PhD** much needed?
- **Does Branch matter**?
- Timeline of the process from applying Research opportunities Career
- Research Internship Vs Technical (SDE, DS, ...) Internship
- Research paper necessary or beneficial for Grad School admissions?
- How to find a problem or look for something to research on or solve it?



# $\bigcirc$

- Failure is common in research It's a stepping stone!
- Always keep your advisor/collaborator in the loop
- Persistent Hardwork Keephustling Go the Extra Mile!
  - Never say 'Settle down'
- Set expectations for your project
  - It's never late to start with research

# Avoiding **common** pitfalls

• Learn required skills on the way Don't fall into the trap of learning all the prerequisites before starting

# Resources for further use



### **Machine Learning Research**

#### $\rightarrow$ What is ML/AI



Hey DALL-E, draw a photorealistic picture of Teddy bears working on new Al research on the moon in the 1980s.

#### DALL·E 2





See also: https://www.autodraw.com/ https://copilot.github.com/

### How to Start

- → Start with basic courses.
- → Search for a peer group.
- → Start and complete a basic project.
- $\rightarrow$  Learn required skills on the go.
- → Contact with seniors and experts in the field.
- → Do Kaggling side by side
- $\rightarrow$  Scout for a good projects with experienced people.

### What to expect

- $\rightarrow$  Fast paced.
- → Infinite number of possibilities to try.
- $\rightarrow$  High Paid.
- → Very Hyped.
- → Very broad field with limitless applications.



What is Robotics??!!

1) Robotics is an interdisciplinary field involving mechanical, electrical, electronics and software engineering.

2) It deals with building intelligent machines that help make human lives easier.





















Deep interpretable non-rigid structure from motion. (Ours)









Sistin . Object













#### Why is Robotics Important?















### What does Robotics Involve?



### How to get started in Robotics?

- → Start with building some basic projects in Robotics.
- → Learn and explore about various Electronic boards, Design Softwares, Simulation environments etc.
- $\rightarrow$  Explore the area in which you want to research further.
- → Do some basic courses in areas like ML, Self Driving Cars, Control Systems, Solidworks etc.
- → Preferably learn ROS(Robot Operating System)
- → Go to Programming Language for robotics projects is Python.

### **Breaking Through into Robotics Research**



### What does Robotics Research Involve?













### **Applications of Robotics!**

- Surgical Robotics
- Warehouse Management
- Self Driving Cars
- Agriculture
- Autonomous Delivery
- Collaborative Robots
- Humanoid Robots etc.













### **Career opportunities in Robotics:**

- ✤ Academia
  - ≻ India:
    - IIIT Hyd Robotics Research Centre, IISC Bangalore, ...
  - ➤ Abroad:
    - CMU, MIT, Stanford, UC Berk, ETH Zurich, QUT Robotics, Mila, Gatech, ...
- ✤ Industry (R&D)
  - ➤ India:
    - Warehouse Robotics (Addverb, Grey-orange), Swaayatt Robots
  - ► Abroad:
    - Google Brain, DeepMind, Meta AI, Amazon Robotics, Skydio, Boston Dynamics, NASA JPL, NVIDIA Robotics, …

# Quantum Computers and Quantum Computing

## Quantum Revolution 1



1956 5MB IBM Hard drive

Current 1 TB Hard Drive

### Quantum Revolution 2



IBM Eagle Quantum Computer (127 Qubits)



How does it look on the inside?



Zooming in on the Qubit Processor



# The Quantum Processor

# Assembly of Eagle


# Difference between Classical Computer and Quantum Computers

- Bits v/s Qubits
- Quantum Supremacy

### Research Fields in Quantum Computing

# Quantum Simulation

- To simulate quantum system we need to model the quantum interactions and need to "teach" quantum mechanics to the computer.
- Classical Computer require a large amount of computational power to simulate quantum phenomena.
- Simulating quantum systems using another quantum system makes it easier as we don't need to teach it.
- Quantum computer itself works on the principles of Quantum Mechanics.

# Quantum Cryptography

- Encryption based on the fundamentals of Quantum Physics
- Unconditionally secure
- Does not depend on the computational strength of any computer

# Quantum ML

Quantum machine learning combines quantum computing with machine learning algorithms to give solutions for problems that are very difficult to solve in a conventional way. QML has emerged due to the current issues with big data processing.

### Quantum Finance

- Interdisciplinary field involving economics and quantum computing that is focused on solving finance problems that are intractable by the classical computers.
- For example- Market Study and Analysis, Study of stock market before a change in the almost continuously changing Market

# Career opportunities in Quantum Industry

Quantum Computing Jobs	Average Salary	Projected Growth		
Quantum Software Engineer	\$107,251	22 percent*		
Quantum Computing Scientist	\$94,488	22 percent"		
Quantum Physicist	\$120,172	8 percent		
Quantum Developer	\$100,135	22 percent*		

# NANOTECHNOLOGY

# CLICHÉ











#### Zoomed 100,000,000x

ATOMS ogo ogo 0000 666600 800000 0000000000 BEHAVES ONE WAY

000000 . . . . . . . 000000 000000 BEHAVES ANOTHER WAY

















#### Glowing Plants Programmable Clothes Flex Electronics







#### Superconductivity

**Nanorobots** 

**Smaller ICs** 



ELECTRONICS



MATERIALS



MEMS/NEMS



MICROFLUIDICS



NANOBIOTECHNOLOGY



NEUROELECTRONICS



PHOTONICS



TECHNOLOGY DEVELOPMENT

# **KICKOFF**

- Google
- Read: Quantum Mechanics, Electrodynamics, etc.
- Work in the institute lab during semesters.
- Apply for summer research interns at various institutes: IISc, TIFR, IISERs, JNCASR, IITs, etc.

# SCAN FOR MORE



# **Fundamental Physics**

- ⇒ Study of physics at the most fundamental level
  - Goal is towards a deep understanding of Space, Time and Matter itself.





#### **Founding Pillars !**

#### **Theory of Relativity**

#### **Quantum Mechanics**





#### **Defective Bombs :**



So, can you figure out a strategy to tell me with certainty, if this bomb is working or not?\*



\* Without of-course exploding the bomb duh

So, can you figure out a strategy to tell me with certainty, if this bomb is working or not?\*

In a world governed by laws of classical mechanics, its Impossible



\* Without of-course exploding the bomb duh

So, can you figure out a strategy to tell me with certainty, if this bomb is working or not?\*

In a world governed by laws of classical mechanics, its Impossible



However, because we live in a world governed by laws of Quantum mechanics, We can indeed have some strategy to identify the working bombs!\*

\* Without of-course exploding the bomb duh

#### **Aerial View of the Large Hadron Collider in Geneva**





### 4<sup>th</sup> July 2012 ! Higgs Boson Discovery !



#### Including Neutrino Physics !

What about Dark matter, Dark energy ?

Gravity at Quantum scales ?

Matter - Anti-matter Asymmetry ?

String Theory, SuperSymmetry, ...

#### **Various Opportunities**

Work as a Researcher @ CERN or countless other Particle Physics experimental setups like SLAC, FermiLab, DESY, EIC, DUNE, SNOLABS, ...

 $\implies$  Conduct research through academic mediums as a faculty or research assistant

#### **Relevant starting skills**

First Read/Study Non-relativistic Quantum mechanics, and see if you really like the mathematics involved\*\*

Introduction to Quantum mechanics by D.J Griffiths

MIT – 8.04, 8.05 OCW Video Lectures, by Prof. Barton Zwiebach

Quantum Physics Video Lectures, by Prof. V. Balakrishnan at IIT Madras

\*Introduction to Elementary Particles by D.J Griffiths (For Particle Physics introduction)

\*\* Don't try to confuse yourself with 'conceptual' understanding, just shut up and calculate

### Thank you for listening!



# Extra slides

force	E&M	weak	strong		gravity
range	$\infty$	$10^{-16} { m cm}$	$10^{-13} { m cm}$		$\infty$
strength	$\frac{1}{137}$	$\approx \frac{1}{30}$	$\approx 1$	] [	$pprox 10^{-38}  rac{E^2}{m_P^2}$
particle	photon	W and $Z$	gluons		graviton?
mass	0	$\approx 100 m_P$	0 or $\approx m_P$		0

"Known" Forces

# LET'S UNDERSTAND WHAT IS CLIMATE PHYSICS



#### IS IT A FACT THEORY, HYPOTHESIS OR A MYTH

 In my opinion nothing is correct. I haven't been careful enough in defining my terms! What do I mean by "GLOBAL WARMING" and what do I mean by "FACT", "THEORY", "HYPOTHESIS" and "MYTH".

#### WHAT DO I MEAN BY "GLOBAL WARMING"?

Need to be more specific in what we state:

- 1. Does the presence of the atmosphere raise temperatures on earth (is there an atmospheric greenhouse effect)?
- 2. Are CO2, methane, CFCs, N2O contribute to this effect (are they greenhouse gasses)?
- 3. Are humans causing greenhouse gasses to increase in the atmosphere?
- 4. How big a temperature rise is this causing/will this cause?

Additional questions (not purely scientific!!!)

- 5. What will the consequences of such a temperature rise be?
- 6. How much will it cost to deal with/avoid consequences?
- 7. What should we do about it?
### IS IT THE TIME TO PANIC ?

• If you are a good grand grandfather/grandmother than you should.

### WHAT IS THE SOLUTION ?

• Start building walls as soon as possible.

### HOW CLIMATE PHYSICS AND OCEANOGRAPHY RELATED??



### WHAT IS OCEANOGRAPHY??

Maths + Physics + Computer Simulation

### **MY JOURNEY TO POLAR OCEANOGRAPHY.**

 Aerodynamic → Fluid Mechanics → Computational Fluid Dynamics → Mathematical Modeling → Oceanography → Polar Oceanography → Might be Theoretical Mathematic.









### **CURRENT WORK**



"I do a lots of maths and coding which runs on a super computer."

### The Dynamics of Mixed Layer Deepening during Open Ocean Convection

Taimoor Sohail, Bishakhdatta Gayen and Andrew McC. Hogg

The Australian National University, The University of Melbourne, and Indian Institute of Science

### FUTURE JOB PROSPECTIVE

• Some people work to keep your life going and some work to answer your existence.







ADVICE

 Learn as much Mathematics as you can, it will give you an extra wing. You will never be ready for anything mf. So get in there and try.

### 3. Go as far as you can.

Chose that path where you will never count your steps.

### 5. Make friends! Good friends.

### THE END

### Fortunately! Unfortunately! It never really is ...

### RESEARCH IN ASTROPHYSICS ASTRONOMY A BRIEF OVERVIEW





### IT'S NOT ASTROLOGY!!!

Astronomy is the study of everything in the universe beyond Earth's atmosphere. That includes objects we can see with our naked eyes, like the Sun , the Moon , the planets, and the stars



# INFORMATICS STATISTICS ASTRO PHYSICS INSTRUMENTATION

## A FEW TOPICS



### **Theoritical Astrophysics**

Theoretical astrophysical phenomena can involve several areas of physics, including atomic physics, nuclear physics, condensed-matter and plasma physics, super-fluidity, general relativity, quantum-field theory and string theory.

### **Observational Astronomy**

Observational astronomy is a division of astronomy that is concerned with recording data about the observable universe, in contrast with theoretical astronomy







### **Computational Astronomy**

Computational astrophysics refers to the methods and computing tools developed and used in astrophysics research

### PREREQUISTES FOR STARTING RESEARCH IN ASTRONOMY

### 01

Basic terms and terminologies used in the subject, ie, a basic overview of the subject

### 02

Any programming language(preferebly Python)







# THANK YOU

