The Demanding Reliance on AI in Scientific Fields

Introduction for Our Biomedical Engineering and Other Engineering Students

Although addressed specifically to our Biomedical Engineering Graduate Students, this note will have university-wide implications for changing curricula across all programs.

A. Bioinformatics

Definition:

Bioinformatics. [The following is a definitional talking point excerpted from Google Search]

Bioinformatics is an interdisciplinary field that uses computational tools and techniques to analyze and interpret biological data, particularly large and complex datasets, to gain insights into biological systems and processes.

Here's a more detailed explanation:

- **Interdisciplinary Nature:**
  Bioinformatics combines knowledge and skills from biology, computer science, mathematics, statistics, and other relevant fields.

- **Data Analysis:**
  It focuses on analyzing and interpreting biological data, such as DNA sequences, protein structures, gene expression patterns, and other genomic and proteomic data.

- **Computational Tools:**
  Bioinformaticians use various computational tools and algorithms to store, retrieve, analyze, and visualize biological data.

- **Applications:**
  Bioinformatics has numerous applications, including:
  - **Genomics and Proteomics:** Studying the structure, function, and evolution of genomes and proteomes.
  - **Drug Discovery and Development:** Identifying potential drug targets and predicting drug efficacy.

- **Disease Research:** Understanding the genetic basis of diseases and developing new diagnostic and therapeutic approaches.
- **Evolutionary Biology:** Analyzing evolutionary relationships between species and understanding the mechanisms of evolution.
- **Personalized Medicine:** Tailoring medical treatments to individual patients based on their genetic makeup.

- **Bioinformaticians:**
  Professionals in this field are called bioinformaticians, and they often develop software tools and algorithms to analyze biological data.

- **Examples:**
  - Analyzing DNA sequences to identify genes and mutations.
  - Predicting protein structures from amino acid sequences.
  - Identifying patterns in gene expression data.
  - Developing algorithms for sequence alignment and phylogenetic analysis.

Example Learning Tools:

In presenting courses on Bioinformatics, we normally rely heavily on the learning tools from **Virtual Labs India** [https://www.vlab.co.in/search].

The Home page for the learning resources is Here: https://bds-au.vlabs.ac.in/Introduction.html

And their Introductory note is helpful:

> Bioinformatics and Data Science in Biotechnology Lab
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> In this lab, students will be able to learn and practice basics of R programming. Students can expand their skillset in R programming by reading and writing biological sequence data in R platform. Educating this will allow users to learn how to use R as an open source language for learning bioinformatics data processing. Specifically, this lab

will help analyze biological sequence data using simple R code snippets. With the features such as flexibility, data handling and modeling capabilities, R programming has been a widely accepted software tools for bioinformatics. It also supports the creation and use of self-describing data structures. With the trends in data science, the lab focuses on FOSS implementations which can be further utilized as laboratory manual or reference material for life science students.

and the full list of experiments is Here:
https://bds-au.vlabs.ac.in/List%20of%20experiments.html

Bioinformatics and Data Science in Biotechnology Lab

1. Writing and reading sequence data in R
2. Guanine-Cytosine content analysis and basics of DNA sequence statistics
3. Pairwise sequence alignment of Protein or DNA sequences
4. DNA sequence analysis and determining DNA open reading frames
5. Reading Fasta using SequinR
6. Querying NCBI database in R
7. UniProt Protein Sequence Retrieval in R
8. Gene finding: Finding Start and Stop codons using R
9. Retrieving a list of sequences from UniProt
10. Computing scoring matrices for amino acids and long pairwise alignment in R
11. Calculating genetic distances between protein sequences
12. Differential expression analyses of RNA-seq

So, the above is what we would ordinarily be teaching concerning **Bioinformatics**.

What is this really? It is learning a coding process, in this case using R. As further noted in V Labs: “Popular programming languages such as Java and Python were the choice of programmers for working in bioinformatics and computational biology. R is a simple programming language, and a free software environment meant for statistical analyses such

as linear and nonlinear modeling, time-series analysis, classification, clustering and for computing and other graphical representations."

That "coding" is essentially dead as far as Bioinformatics is concerned is clearly demonstrated in the paper by Hamid Jamialahmadi, et al. **"Artificial intelligence and bioinformatics: a journey from traditional techniques to smart approaches"**, stating:

> The incorporation of AI models into bioinformatics has brought about a revolutionary era in the analysis and interpretation of biological data…We explored the diverse applications of AI methodologies, including machine learning (ML), deep learning (DL), and natural language processing (NLP), across various domains of bioinformatics. These domains encompass genome sequencing, protein structure prediction, drug discovery, systems biology, personalized medicine, imaging, signal processing, and text mining. AI algorithms have exhibited remarkable efficacy in tackling intricate biological challenges, spanning from genome sequencing to protein structure prediction, and from drug discovery to personalized medicine. In conclusion, this study scrutinizes the evolving landscape of AI-driven tools and algorithms, emphasizing their pivotal role in expediting research, facilitating data interpretation, and catalyzing innovations in biomedical sciences.
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> Jamialahmadi H, et al. "Artificial intelligence and bioinformatics: a journey from traditional techniques to smart approaches" Gastroenterol Hepatol Bed Bench 2024;17(3):241-252. https://doi.org/10.22037/ghfbb.v17i3.2977).

AI systems and applications are coming on very strong for writing code of any kind. Consequently, at Blue Marble University, we believe the future is not in learning or writing code, but rather in implementing AI systems to achieve the same ends. There will always be a need for computer scientists to know coding in order to teach the AI models. Or for machine learning of Big Data. But for working scientists in various disciplines, writing code or learning code is not going to be necessary, and possibly that future is already here.

At Blue Marble University, we see the future in learning about AI systems and what they can be used for, in other words, a more cross-disciplinary education in AI systems and applications.

B. Robotics

This is a massive field. We all intuitively know what we are talking about, from automobile manufacturing to more precise things like drawing a patient's blood for a blood test. Yes, there is a robotic device for this too!! And recently, a humanoid robot that can now do a flip.

When we consider **Biomedical Engineering**, what are some of the things we might be interested in? Possibly robotic arms and legs for the disabled? Maybe health monitoring or humanoid caregiving? Robotic surgeries of course.

Again, just as we mentioned above for Bioinformatics, the field of robotics is being rapidly merged with AI. It is AI that gives the mechanical mechanisms the "brain" to work.

An excellent starting point that gives the basics of robotics is the Virtual Labs-India "Mechanics and Robotics Lab" with their list of experiments https://mr-iitkgp.vlabs.ac.in/List%20of%20experiments.html

Mechanisms and Robotics Lab

1. Movemaster
2. Forward Kinematics of PUMA 560
3. Inverse Kinematics of PUMA 560
4. KGP 50
5. Oldham Coupling Mechanism
6. A quick return mechanism
7. CAM follower mechanism
8. Robot Teaching Using VAL Programming

We still believe that learning some of the rudimentary aspects of robotics is useful in understanding how to use or benefit from AI-Robotics.

However, again, as the mechanical aspects of robotics are also superseded by AI created robotics and robotic instructional techniques, *it is the field of AI that must be emphasized.*

Robots used in auto manufacturing are now viewed as so simplistic, and need no AI for proper use.

And just as we said above for Bioinformatics, at Blue Marble University, we see the future of Robotics in learning about AI systems and what they can be used for, in other words, a more cross-disciplinary education in AI systems and applications.

C. Conclusion

The future is upon us and we all must catch up in order to be a part of and contribute to the ongoing AI revolution.

As a small online university with no experts in AI on staff, our mission is to guide you to the proper sources for your further study and implementation. Moreover, we all learn “on the job”. What is most important is that you learn the main applications for AI in your fields, and the “lingo” of AI systems and applications.

Hopefully, at the end of your adventure with us you can say: Wow, that was good…

Anyway, that is our hope…