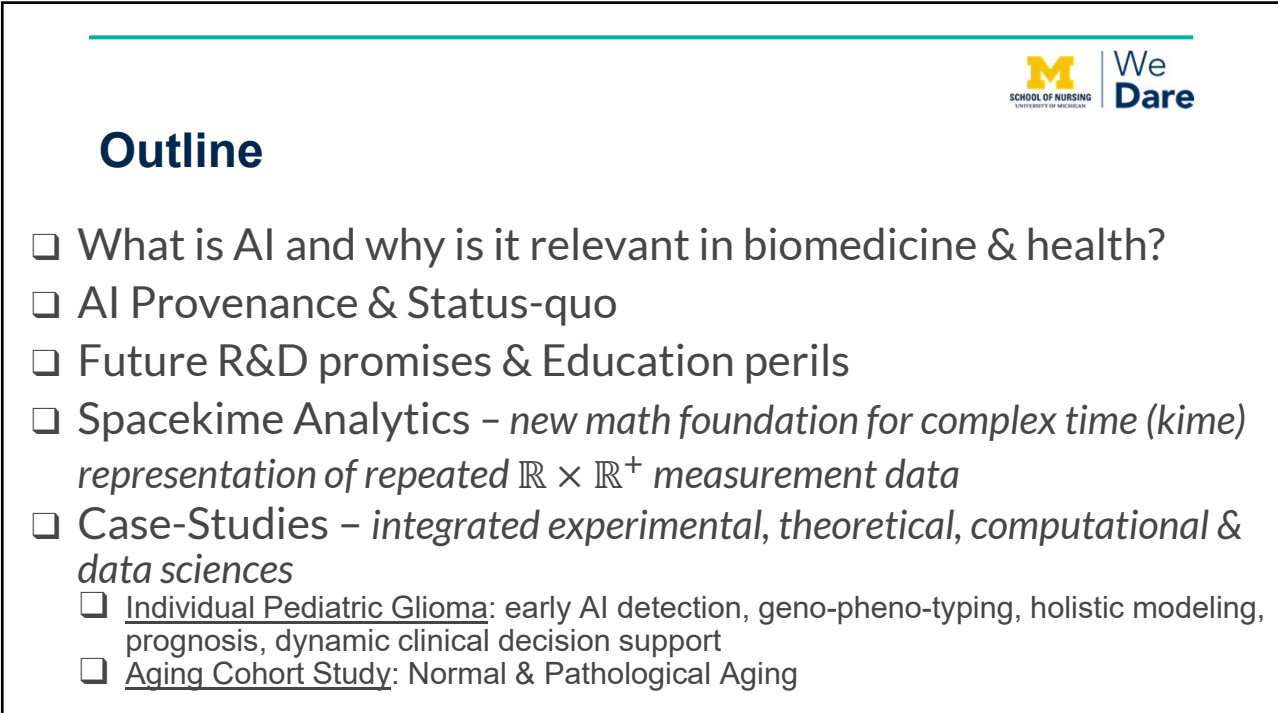# AI Bio-Innovations in Health & Neurooncology

Research Promises, Learning Opportunities & Clinical Practice Impact

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https://www.socr.umich.edu

Slides available online
Google search for "SOCR News"

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Outline

❏ What is AI and why is it relevant in biomedicine & health?

❏ AI Provenance & Status-quo

❏ Future R&D promises & Education perils

❏ Spacekime Analytics – *new math foundation for complex time (kime) representation of repeated $\mathbb{R} \times \mathbb{R}^+$ measurement data*

❏ Case-Studies – *integrated experimental, theoretical, computational & data sciences*
  - ❏ Individual Pediatric Glioma: early AI detection, geno-pheno-typing, holistic modeling, prognosis, dynamic clinical decision support
  - ❏ Aging Cohort Study: Normal & Pathological Aging

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What is AI? Why is it relevant in Health?

(SCHOOL OF NURSING, UNIVERSITY OF MICHIGAN — We Dare)

❑ AI represents a <u>synthetic mockup of common human intelligence tasks & processes</u>.

❑ AI models create virtualized states, processes, actors, actions, and responses. <u>AI manifests as applications, algorithms, or interfaces built as services, tools, apps, or integrated computing environments</u>. AI services attempt to disrupt current protocols, upscale process efficiencies, optimize resources (time, manpower, energy, moneys), and augment human decision-making

❑ AI is predicated on
- Massive amounts of complex, heterogeneous, time-varying & multi-source data (<u>Big Data</u>)
- Integrated computational systems (elastic Clouds) with effective <u>human & machine interfaces</u>
- Efficient <u>data management</u>, aggregation, harmonization, augmentation, processing & Viz
- Sophisticated techniques (methods) and <u>advanced algorithms</u> (software)

❑ Relevance in Healthcare (PMC8437645, PMID36626192, PMC4795481, PMC8550565, PMC7031195, ISBN 978-3-031-17482-7)
- <u>More biomed data are created daily to enhance healthcare than can be humanly processed</u>
- Significant <u>opportunities exist to optimize existing processes</u> (e.g., process time-reductions, cost-efficiencies, lower environmental-impacts, improved clinical outcomes, strengthen education & training, enhanced health-equity, expedite global health advances)

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AI Provenance

(SCHOOL OF NURSING, UNIVERSITY OF MICHIGAN — We Dare)

❑ Ancient Greek artisans designed the bronze Greek mythology giant Talos to guard the island of Crete by imaginatively throwing boulders at hypothetically invading ships (300 BC)
❑ The Persian scholar Al-Jazari's programmable automata, mechanical devices (1206 AD)
❑ Leibniz & Descartes suggested that all *rational thought could be made as systematic* as algebra or geometry & reduced to mechanical calculation (late 1680's AD)
❑ Many historic accounts attest to early attempts to *imagine* artificial intelligence
- Myths, fairytales, stories and rumors of inanimate objects endowed with intelligence or consciousness by master craftsmen, e.g., Frankenstein (1818 AD), Pinocchio (1883 AD)

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❑ Invention of a programmable digital computer (1940 AD), algorithmic machine abstraction of mathematical reasoning
❑ Turing Test (Alan Turing) – creating machines that think (1950 AD)
❑ *"Dartmouth Summer Research Project on Artificial Intelligence"* McCarthy (1955 AD)
❑ _____ AI Winter_____
❑ Deep Blue beat a reigning world chess champion Garry Kasparov (1997 AD)
❑ Deep Learning Networks, GPU computing (2012+ AD)

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Present AI Status-quo

❑ Latest AI can
   (1) Synthetically <u>simulate intelligent text responses</u> prompted by human text/voice. Write papers, bios, grants, clinical notes, prognoses, speeches, reviews, summaries, etc.
   (2) <u>Simulate realistic 2D brain images</u> of specific clinical phenotypes and image-modalities
   (3) <u>Write software code</u> driven by simple commands, verbal descriptions, or human language

❑ AI relevance
   ▪ <u>Students</u> are already using AI Chat Bots for completing homework assignments
   ▪ <u>Researchers</u> are using crowdsourcing and AI to derive theoretical results
   ▪ <u>Practitioners</u> are utilizing AI in clinical applications (e.g., tissue-cell classification, reading MRIs)
   ▪ <u>Stakeholders</u> are demanding rapid Dx, optimal Tx plans, low costs, process efficiencies, improved population outcomes, and better policies

❑ Most people <u>use/encounter AI technology in many aspects of their daily experiences, but few have formal training in AI ethical-use & reliable-development</u>

❑ *Difficult tasks*: AI design, training, tuning & validation (time, resource & infrastructure intensive)
❑ *Expeditious tasks*: AI applications, testing, forecasting, classification & clustering

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Future AI promises & potential perils

❑ Promises
   ▪ Radically transform formal <u>education</u>, informal learning & vocational training
   ▪ Catapult scientific <u>discoveries</u> (theoretical, experimental, computational & data sciences)
   ▪ Democratize <u>access to knowledge</u> & level certain playing fields
   ▪ Augment many <u>decision-making processes</u> & automate various tedious tasks

❑ Potential Perils
   ▪ Potentially rapid <u>AI-divide</u> (accessibility imbalance between haves & have-nots)
   ▪ Potentials for <u>training biases</u> & balance <u>AI precision</u> & <u>variability</u> (tradeoffs)
   ▪ Instead of aiming to ban, stifle & control AI immersion, we need to embrace it, manage it, and <u>use it for "*social & environmental good*</u>" –
      ▪ Recall how <u>airplanes became the safest mode of transport</u>, safer than cars, bikes & running shoes
   ▪ Continuity in "*…the ultimate AI is just about to arrive …*" (always 10 years in the future)
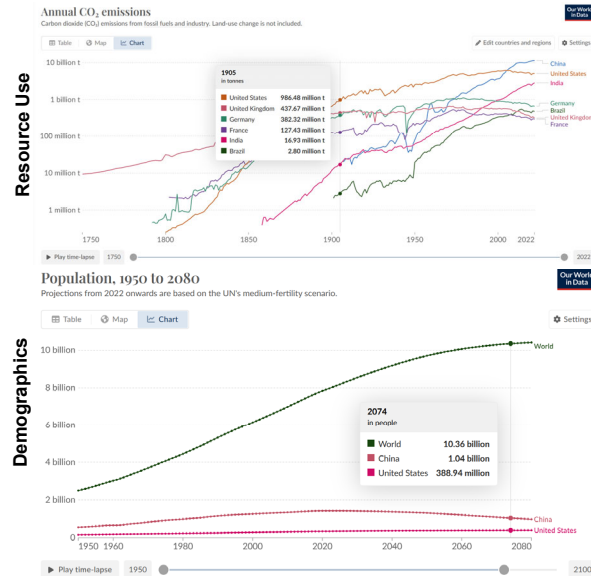
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What drives AI into the Stratosphere?

❑ Forward-Looking Human Nature (Demands)
- Resource utilization demands per capita (energy, consumables, natural resources) $\mathbb{E} \uparrow$ (expected)
- Productivity growth pursuits & better experiences for everyone, everywhere, all at once

❑ Demographic Changes
- *Rich-World*: Working-age population is expected to peak in this decade (by 2030) throughout the Organization for Economic Co-operation & Development (OECD) Countries
- *China*: Working population peaked in 2015

❑ Relentless Digitalization & Virtualization of most Human Experiences

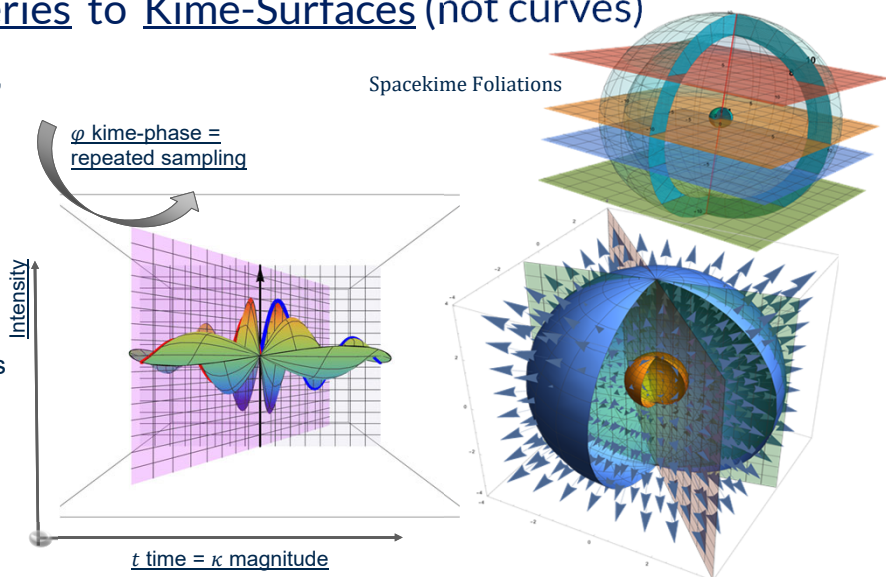https://ourworldindata.org/population-growth

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Complex-time (Kime) Representation

❑ From Time-Series to Kime-Surfaces (not curves)

In the 5D spacekime manifold, time-series curves extend to kime-series, i.e., surfaces parameterized by kime-magnitude (t) and the kime-phase (φ).

Kime-phase aggregating operators that can be used to transform standard time-series curves to spacekime kime-surfaces, which can be modeled, interpreted, and predicted using advanced spacekime analytics.
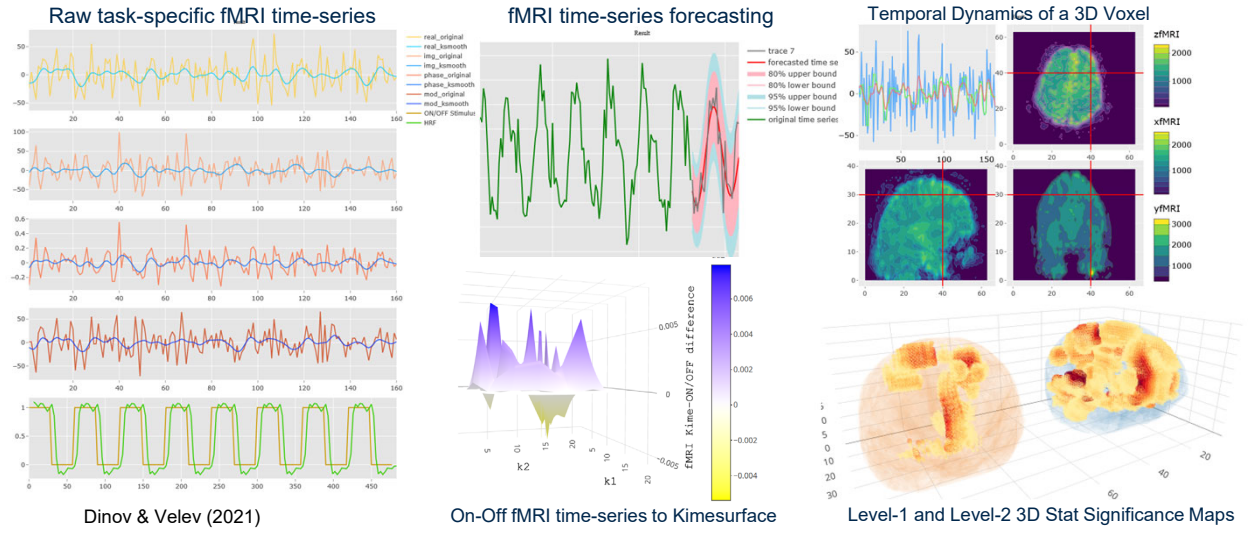

Spacekime Foliations

φ kime-phase = repeated sampling

Intensity

t time = κ magnitude

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Complex-time (Kime) & Spacekime Analytics

❏ Complex-valued finger tapping fMRI ($64x * 64y * 40z * 160t$)

Raw task-specific fMRI time-series

fMRI time-series forecasting

Temporal Dynamics of a 3D Voxel

Dinov & Velev (2021)

On-Off fMRI time-series to Kimesurface
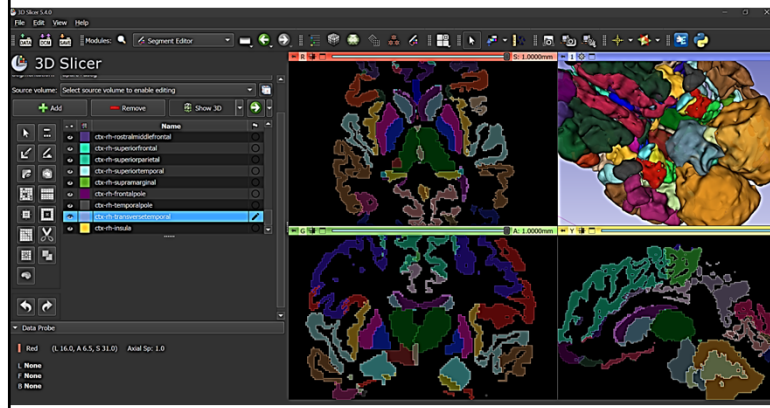
Level-1 and Level-2 3D Stat Significance Maps

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Individual Study: *Pediatric Brain Cancer*

❏ In kids, thalamic pediatric high-grade gliomas (HGGs) accounts for 13% of child HGGs and 5% of all pediatric brain tumors, low gliomas (LGGs) tend to be more common

https://doi.org/10.1093%2Fneuonc%2Fnor045 | https://doi.org/10.3390%2Fgenes13040624

3D ROI Differences (Follow-up vs. Baseline)

Structure	Region ID		Raw Differences		Normal Brain Atlas Statistics			
ROI Name	Ind	Seg ID	# Vox	Vol mm³	norm Mean	Norm StdDev	norm Min	norm Max
Left-Lateral-Ventricle	1	4	0	-0.1	15.94	16.37	0	87
Left-Inf-Lat-Vent	2	5	0	0.6	41.61	15.28	12	80
Left-Cerebellum-White-Matter	3	7	0	-0.2	81.48	10.84	29	130
Left-Cerebellum-Cortex	4	8	-29	-29	59.33	14.39	14	180
Left-Thalamus	5	10	0	1.5	74.92	11.55	25	168
Left-Caudate	6	11	0	-1.1	69.50	10.94	18	118
...					...	...	...	...

Goal: Early AI detection, geno-pheno-typing, holistic modeling, prognosis, dynamic clinical decision support
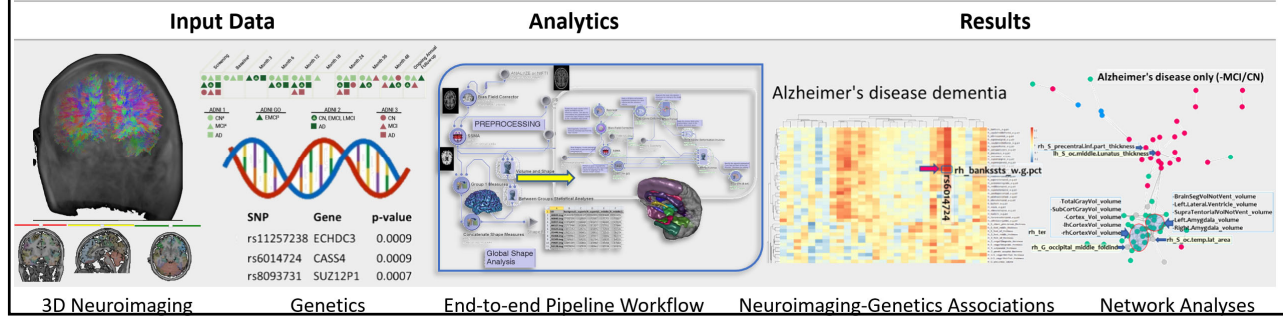
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Cohort Study: *Normal & Pathological Aging*

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❑ **Problem** – Model age-related cognition in 3 participant cohorts – (1) *Asymptomatic Controls*, *(2) Mild Cognitive Impairment*, (3) *Dementia*

❑ **Evidence** (data types) – *clinical* evaluation (tables), *genetic* information (sequences), and 3D/4D *neuroimaging* (spatiotemporal)

❑ **Status-quo** of clinical care – independent analysis of the 3 different data types followed by inference pooling

❑ **Challenge** – introduce new holistic Health-Analytics Protocol for AI modeling, Dx, classification, and Tx plan using the joint distribution of the entire observed data.
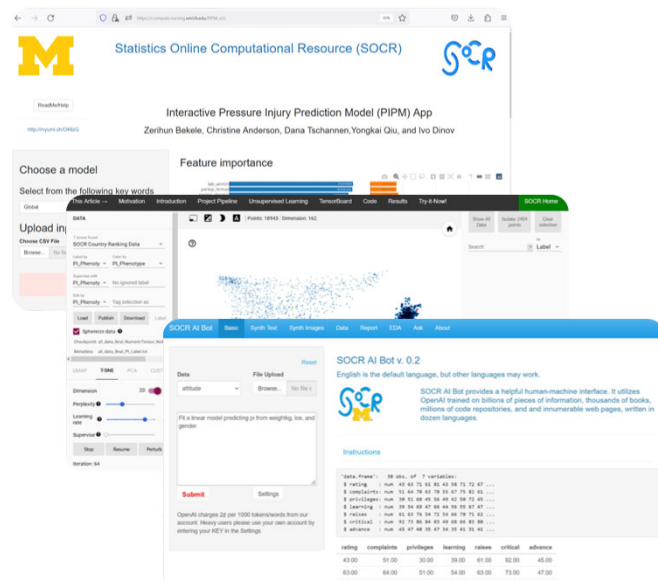
Refs: https://www.socr.umich.edu/people/dinov/publications.html   Apps: https://socr.umich.edu/HTML5/

Input Data	**Analytics**	**Results**

SNP	Gene	p-value
rs11257238	ECHDC3	0.0009
rs6014724	CASS4	0.0009
rs8093731	SUZ12P1	0.0007

Alzheimer's disease dementia

3D Neuroimaging   Genetics   End-to-end Pipeline Workflow   Neuroimaging-Genetics Associations   Network Analyses

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Live SOCR AI Webapps

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❑ Interactive Pressure Injury Prediction Model (PIPM) App (RShiny)

❑ Visual Exploratory Data Analytics (SOCR Tensorboard Webapp)
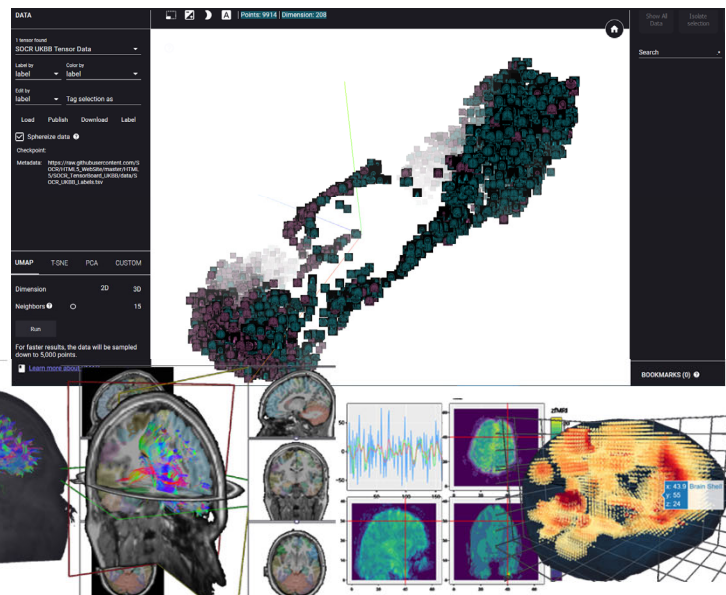
❑ Quantitative AI-driven Analytics (SOCR AI Bot)

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Neuroscience Demos

□ SOCR Dimensionality Reduction App
- 10K participants,
- 200 clinical, imaging, genetics biomarkers

□ SOCR Brain Viewer
- Population Atlas
- Individual Participant

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So what? Highly subjective speculations …

- (Unscientific) Audience Poll – **Are AI-driven cars safer?** (1) Yes; (2) No; (3) Unsure

- Personal implications for each of us individually? Societally? Anthropologically?

- What can we individually/collectively do to respond to, incent, or halt AI advances?

- Strike against AI immersion, protecting *good-paying, manufacturing, white-collar* jobs?

- What is likely to immerge in the next decade?

- AI cost–benefit analysis?

- Short, mid-term & long-term impacts?

- What about AI self-reproduction? AI evolution through "natural selection"?

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Available AI Resources

- SOCR Motto – *"It's Online & Freely Accessible, Therefore it Exists!"*
- Pubs: https://socr.umich.edu/people/dinov/publications.html
- GitHub: https://github.com/SOCR/PressureInjuryPrediction
- PIPM App: https://rcompute.nursing.umich.edu/PIPM_v2/
- AI Apps: https://socr.umich.edu/HTML5/
- SOCR AI Bot: https://rcompute.nursing.umich.edu/SOCR_AI_Bot/
- Demos: https://DSPA2.predictive.space (Appendix 9 – OpenAI Synth Text Img & Code)
- Tutorials: https://TCIU.predictive.space & https://SpaceKime.org
- Websites: https://nursing.umich.edu & https://socr.umich.edu

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