

A field of sunflowers with a dark overlay.

• Will It Get Better?

A Multi-Layered Neural Network with Multivalued Neurons
(MLMVN) Approach to Social Progress Data Prediction

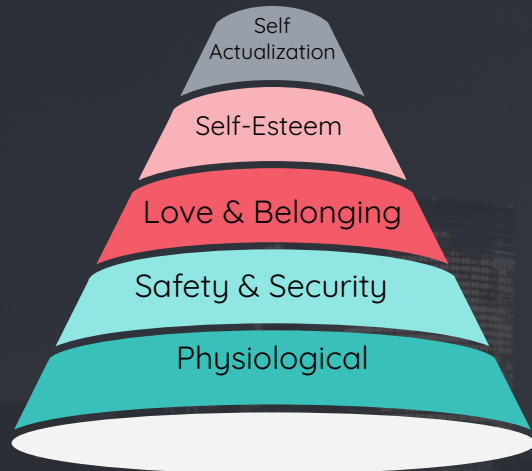
Tiffany French, M.S. Candidate

WHAT IS CONSIDERED IN THIS THESIS

- Why it is important to predict societal progress
- How we define society
- Prediction as a machine learning problem & its mathematical model
- Examples of prediction:
 - Average Wage
 - Premature Mortality
 - Surface Temperature
 - Housing Cost
 - Happiness
 - Gender Equity in government
- A Comparative Evaluation of the United States

WHAT MAKES A SOCIETY? HOW DO WE ASSESS IT?

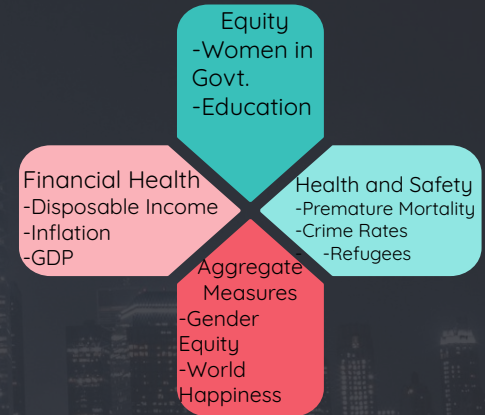
Maslow's Hierarchy



Guns, Germs and Steel



Measuring Society

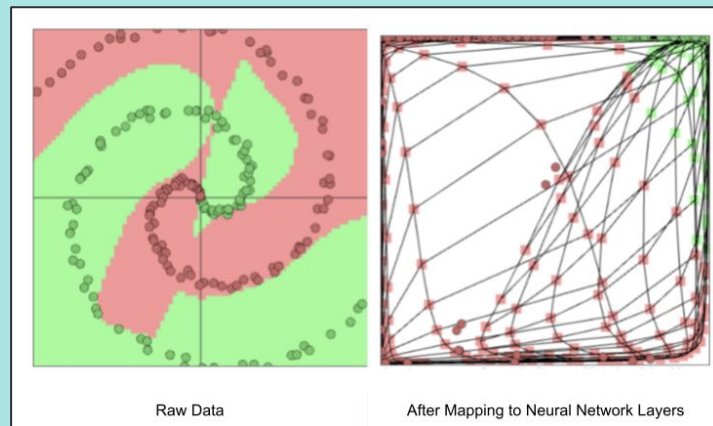


"...the promise of computation is that we can take information and use it to improve people's lives."- Dr. Cynthia Dwork

PREDICTING “BETTER” & METHODOLOGY: MLMVN

Multi-layered Neural Network Multi-Valued Neurons

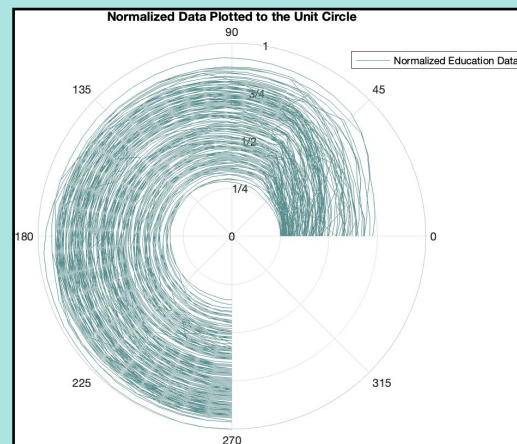
- A Neural Network with a circular complex valued activation function
- User-defined topology with two, or more, hidden layers of neurons
- Allows for subtle analysis of nonlinear data
- Derivative-free backpropagation prevents overfitting, and the local minima phenomenon



PREDICTING “BETTER” & METHODOLOGY

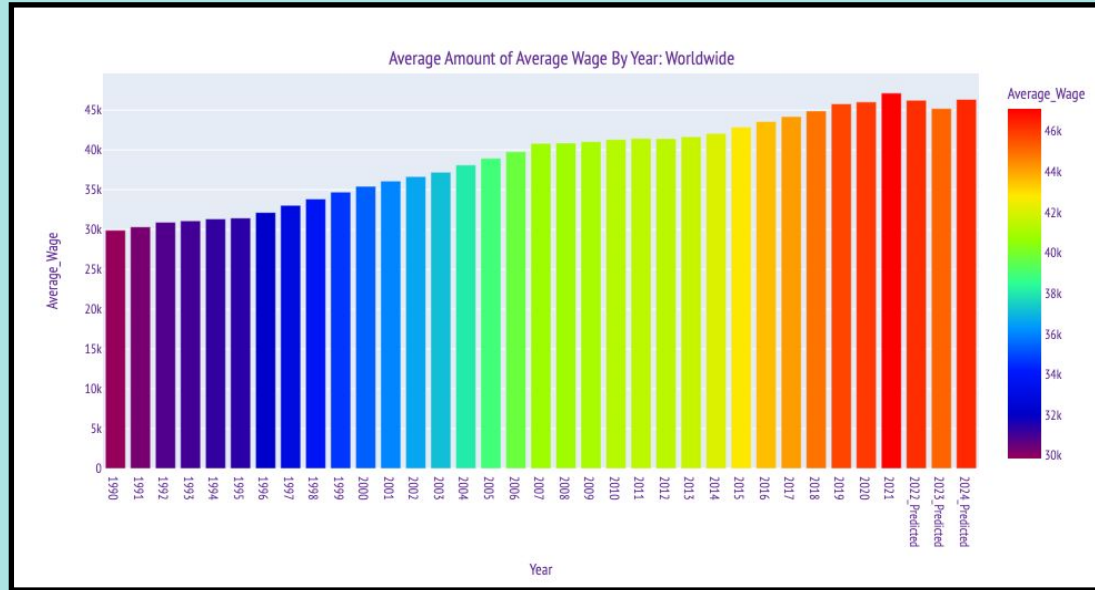
Data Preparation & Processing

- Data was initially cleaned to remove or reasonably adjust outliers
- Datasets were mapped between 0 and 1, and then mapped to $\frac{3}{4}$ of the unit circle.
- Experiments to determine optimal topology.
- Running training and testing, and then capturing predicted values.



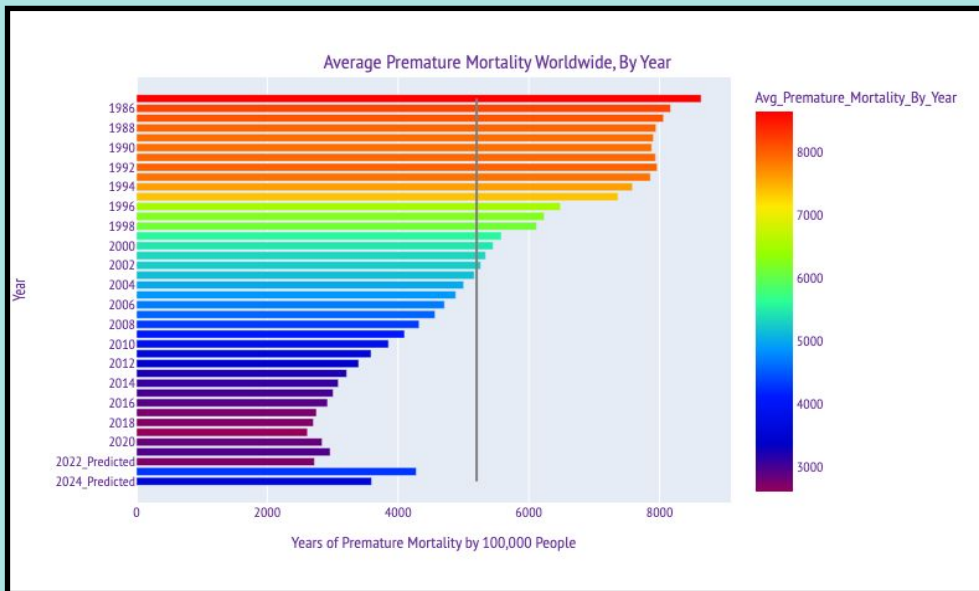
$$x = ((y - \min(y)) / (\max(y) - \min(y))) * 3\pi/2 + \pi/4;$$

Average Wage: Significant Findings



Minimum Value Change from 1990-2024	90.38 %
Median Value Change from 1990-2024	48.68 %
Maximum Value % Change from 1990-2024	44.08 %
%Change in Median in 1993 and 2008	27.62 %
%Change in Median in 2009 and 2024	11 %
% Change in Median Wage Growth Between the Two 15 Year Periods	-60.17 %

Premature Mortality: Significant Findings



Lowest Average Mortality						
Country_Name	1985	2024_Predicted	Average	% Change	Overall Trend	Health System
Japan	3,019.36	1,946.99	1,428.36	-35.52		Universal
Sweden	3,754.43	2,154.12	1,641.74	-42.62		Universal
Switzerland	3,978.67	3,948.73	1,891.40	-0.75		Hybrid
Italy	4,530.94	1,560.82	1,906.88	-65.55		Public Primary
Norway	4,479.47	122.34	1,991.25	-97.27		Universal
Israel	4,706.14	1,047.64	2,072.54	-77.74		Universal
Netherlands	3,989.01	1,501.64	2,122.82	-62.36		Hybrid
Australia	5,075.41	2,927.97	2,238.01	-42.31		Universal
Spain	4,175.91	3,656.69	2,259.18	-12.43		Hybrid
Greece	4,229.18	2,439.92	2,340.60	-42.31		Public Primary

Largest Negative Percentage Change (Most Improvement)						
Country_Name	1985	2024_Predicted	Average	% Change	Overall Trend	Health System
Norway	4,479.47	122.34	1,991.25	-97.27		Universal
South Korea	9,063.47	297.66	3,491.47	-96.72		Universal
Russia	29,892.92	1,192.96	19,444.50	-96.01		Hybrid
Austria	6,062.88	903.74	2,706.61	-85.09		Universal
Slovenia	8,030.75	1,209.09	3,904.44	-84.94		Universal
Ireland	5,705.00	1,104.21	2,706.85	-80.64		Universal
New Zealand	6,330.58	1,274.25	2,991.88	-79.87		Universal
Latvia	25,893.47	5,549.87	14,109.53	-78.57		Universal
Israel	4,706.14	1,047.64	2,072.54	-77.74		Universal
France	5,367.16	1,314.02	2,833.34	-75.52		Universal

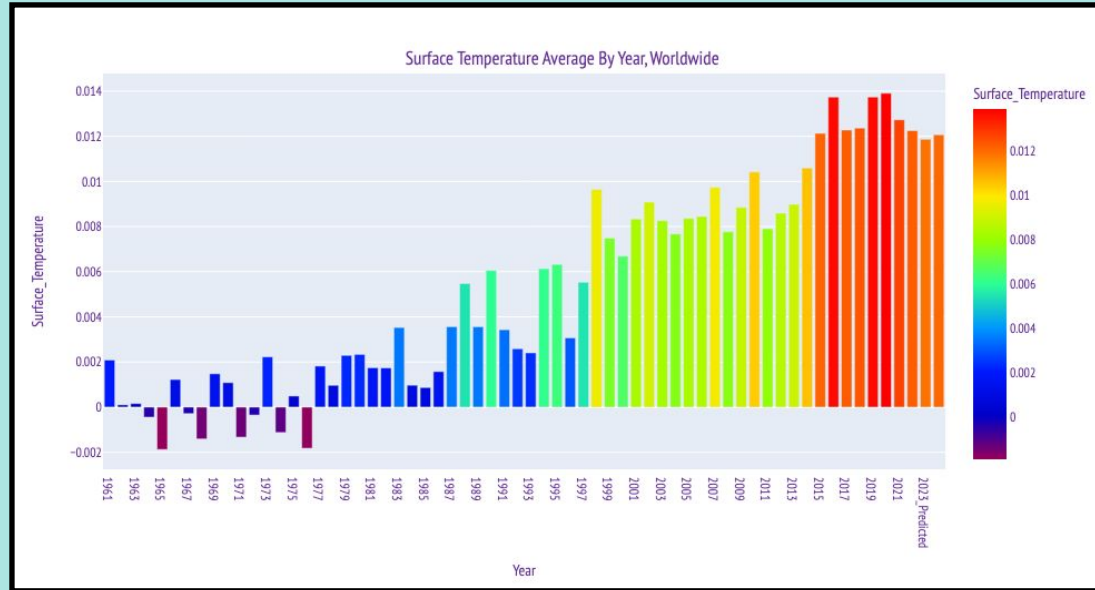
Fig 12b: Percentage Change and Average Premature Mortality

Legend for Health System: Universal = Universal Healthcare, Government Provided.

Hybrid: Universal or Public Option, but, with substantial Privatized Health Sector.

Public Primary: Substantial Publicly Funded Option is primary, but, many private options.

Surface Temperature: Significant Findings



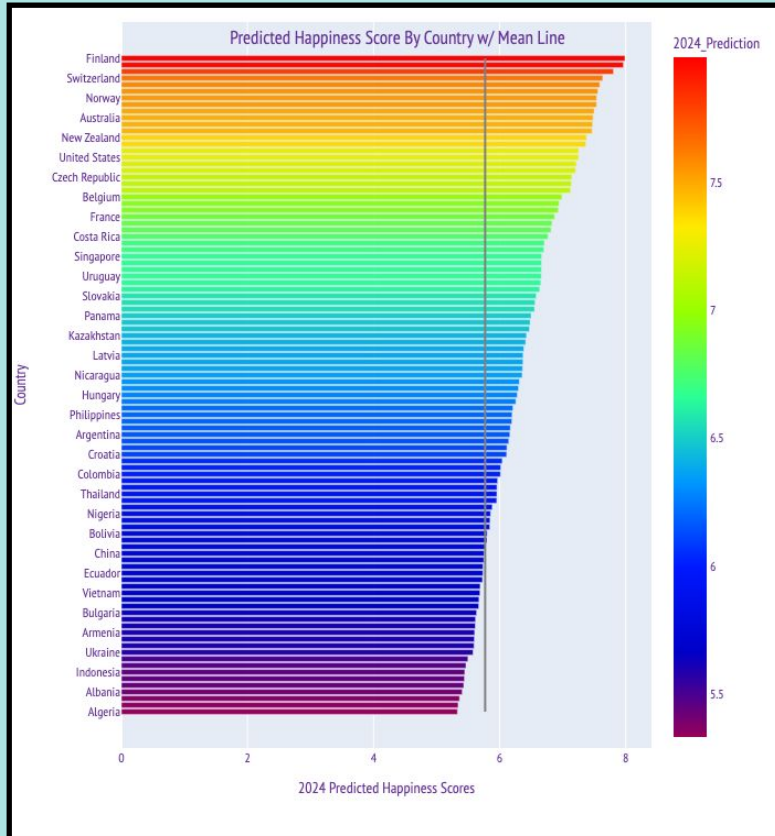
1961	1992
.00208	.002586
% Change from 1960-1992	
23.98%	
1961-1976	1977-1992
-187.44%	29.69%
1993	2024
.002404	.012065
% Change from 1993 to 2024	
401.77%	
1993-2008	2009-2024
222.90%	36.43%

Housing Cost: Significant Findings



1970	1992	1993	2024
687.95	625.46	622.78	737.00
Percentage Change 1970-1992		Percentage Change 1993-2024	
-9.083		18.34	
%Change from 1970-1981	%Change from 1982-1992	%Change from 1993-2008	% Change from 2009-2024
1.145	-7.46	22.47	11.05

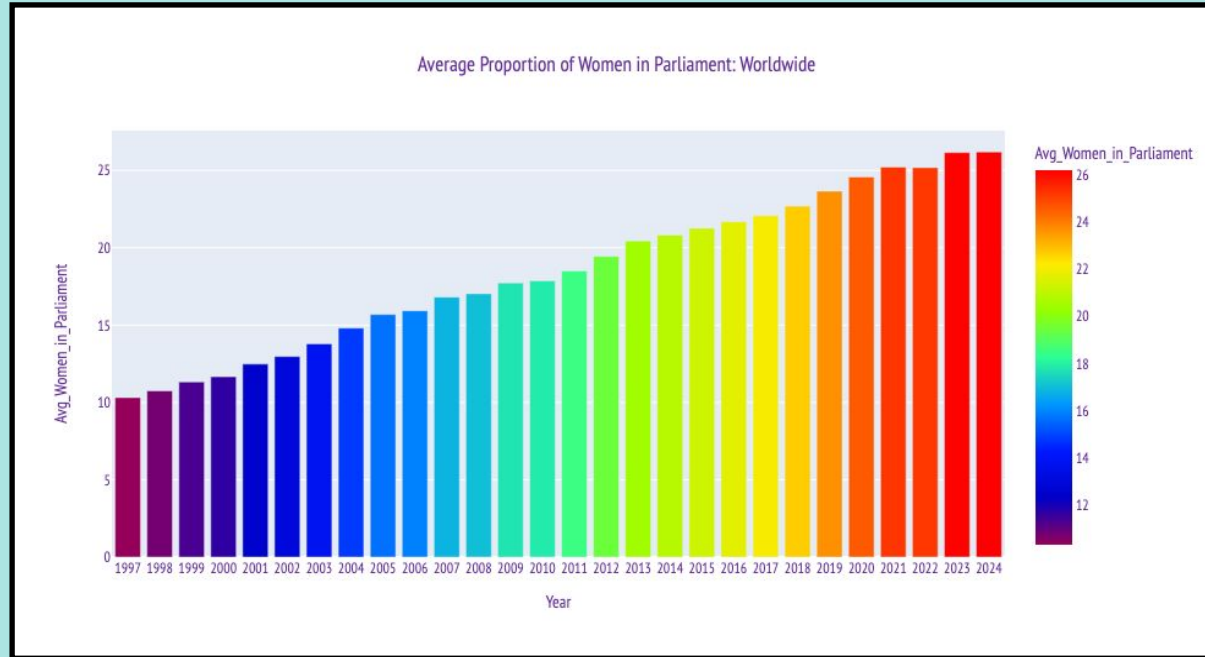
Happiness: Significant Findings



Highest Average					
Country	2015	2024_Prediction	Average	% Change	Trend
Finland	7.58	7.99	7.84	3.54	
Denmark	7.70	7.81	7.76	0.79	
Switzerland	7.75	7.64	7.68	-0.91	
Norway	7.69	7.54	7.64	-0.72	
Netherlands	7.55	7.59	7.59	0.59	
Iceland	7.73	7.22	7.59	-1.76	
Sweden	7.54	7.56	7.52	-0.25	
New Zealand	7.46	7.38	7.45	-0.18	
Australia	7.46	7.48	7.43	-0.39	
Canada	7.60	7.20	7.39	-2.75	
Greatest Change					
Country	2015	2024_Prediction	Average	% Change	Trend
Togo	3.09	4.34	4.06	31.64	
Benin	3.58	4.84	4.58	28.04	
Ivory Coast	3.89	5.44	4.97	27.89	
Burkina Faso	3.82	4.89	4.62	20.80	
Gabon	4.13	5.47	4.93	19.57	
Senegal	4.13	5.26	4.94	19.40	
Niger	4.08	5.28	4.79	17.50	
Hungary	5.01	6.28	5.89	17.40	
Guinea	3.89	4.89	4.56	17.32	
Honduras	5.00	6.55	5.85	16.86	

Percentage Change in Happiness		
Overall Change from 2015-2024	3.07	
2015-2019	0.64	
2020-2024	1.50	

Women in Government: Significant Findings



Countries with Highest Avg. of Women in Parliament	
Country	Mean
Rwanda	49.61%
Cuba	42.36%
Mozambique	37.23%
Iceland	37.89%
South Africa	38.33%
Finland	41.79%
Netherlands	37.35%
Norway	39.38%
Denmark	38.10%
Sweden	44.47%

The United States: In Perspective

Dataset	Rank	Mean
Average Wage	3	From 1990-2024: \$58,387
Disposable Income	1	From 1995-2024: \$40,062
GDP Growth	1	GDP \$ Per Capita: 70,249
Gender Equity	41	GII has decreased 64% over time to .24
Global Education	1	Average Years of Education Per Citizen: 12
Housing Cost Price Index	13	13th Most Expensive Housing Cost: \$754
Inflation	59	A negative -7% decrease in inflation, over time.
Premature Mortality	31	Average 4662 Years of Life Lost per 100,000 people
Women in Parliament	105	An average of 18% Women in Congress since 1997.
World Happiness	14	An average Happiness Score of 7.17 (World Mean: 5.6)

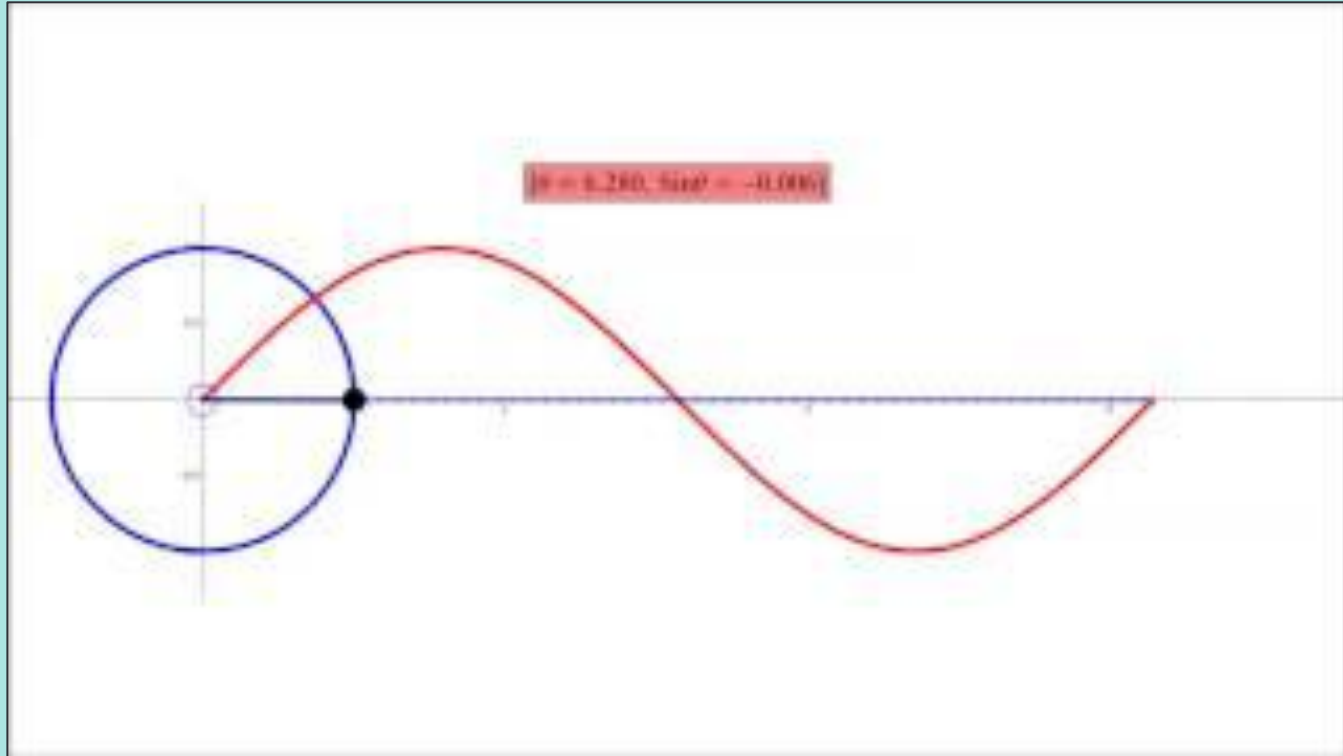
Conclusions & Future Research

- Improve generalization capability.
- Explore causality, and connectedness between datasets.
- Integrate additional datasets to explore causal relationships.
- Multivariate time series predictions based on other historical events.



Questions?

- Example of Sine Wave and Circular Plotting Behavior



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