Economic Tails

work toward understanding tail events

Prof. Alex Pentland, MIT
Abu Dhabi Investment Authority Lab
OECD, UN, Consumer Reports

9-24-23

1. Need to better understand economic instabilites

GameStop
SVB
Crypto-X

first, why are we social?

Hypothesis: for faster spread of innovation
-> Preferential attachment, produces long-tail "swans"
-> non-stationary, non-ergodic, greater individual risk
-> myopia, missing causal variables

All undermine hypothesis testing

Need polynomial more samples, social can deliver
…but as we will see, at the cost of instabilities

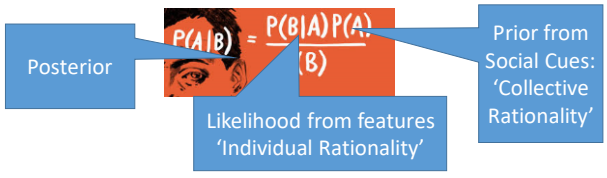
typical individual deductive decision model

Likelihood given features

(limitedly) rational individuals
Compact (e.g., Gaussian) models
Stable models, at equilibrium

how to integrate collective experience into decision? social proof?

social inductive decision model



distributed bandits, Bayesian portfolio aka foraging

Krafft, Tennenbaum, Pentland

from Thompson samping to distributed bandits

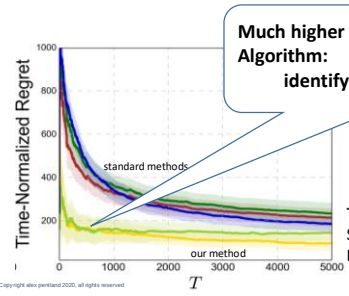
Strong optimality: minimum regret (fast, robust convergence)

Privacy-preserving, robust to adversaries and long-tailed data, low-bandwidth communications

*** Differentially-Private Federated Linear Bandits** ***Neural Information Processing Systems*** **(NeurIPS), 2020 (spotlight)**

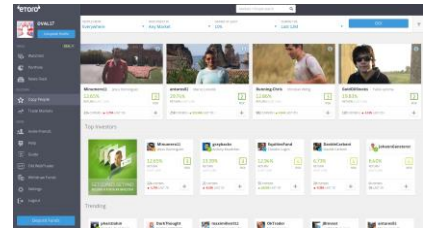
*** Kernel Methods for Cooperative Multi-Agent Contextual Bandits** ***International Conference on Machine Learning*** **(ICML), 2020**

Much better decisions

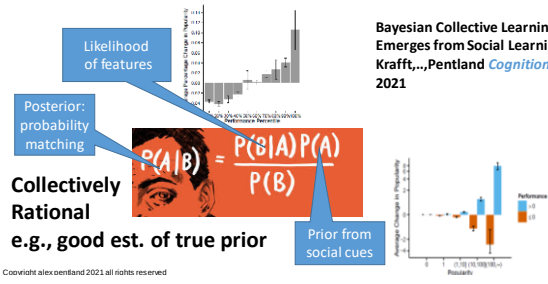


Thompson Sampling on Symmetric α-Stable Bandits
Dubey and Pentland, *IJCAI* 2019

is this good description of human decisions? experiment on the eToro *social* trading platform



*posterior = performance * popularity*



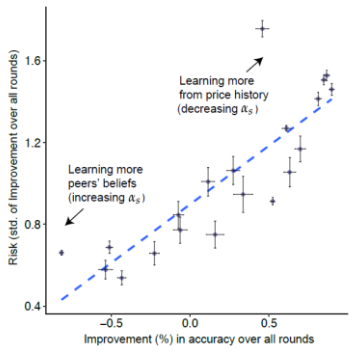
Bayesian Collective Learning Emerges from Social Learning, Krafft,..,Pentland *Cognition* 2021

Collectively Rational
e.g., good est. of true prior

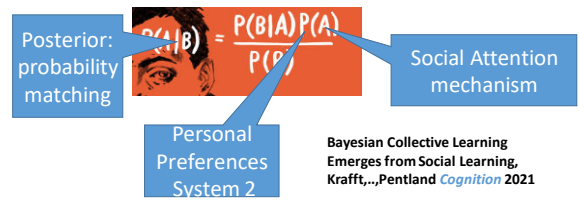
experts too….

Accuracy-Risk Trade-off due to Social Learning in Crowd-sourced Financial Predictions, Adjodah,…Pentland, *Entropy* 2021

Pareto frontier



Potential Biological Algorithm: posterior = system 2 * system 1



Bayesian Collective Learning Emerges from Social Learning, Krafft,..,Pentland *Cognition* 2021

Social Media

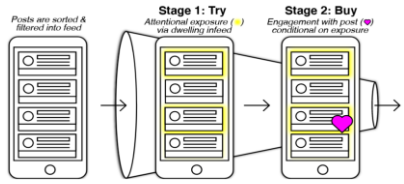


Figure 1: Two-stage try-buy model of attention in social media environments.

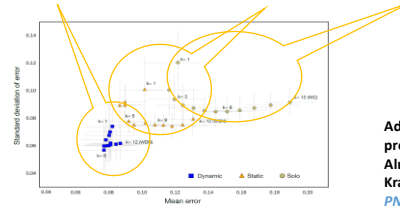
Try: (dwell) was focused on sensational and not credible posts.
Buy: (engagement) was focused on credible and not sensational.

Epstein et al under review, **MusicLab (Krumme et al, PLOS 1**

But:

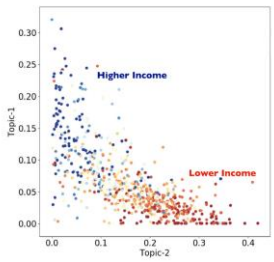
performance depends on similar utilities

similar utility teams > random teams > individuals



Adaptive networks promote wisdom of crowd, Almaatouq, Noriega, Alotabi, Krafft, Pentland
PNAS, **2020**

resulting in on-line echo chambers

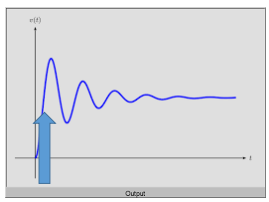


Segregated interactions in urban and online space. Dong, Morales, Pentland, EPJ Data Sci. 9(1): 20 (2020)

2. Does this model correctly predict instabilities?

use of social priors permit cascades

Temporal Dynamics from social prior



An Experimental Study of Cryptocurrency Market Dynamics Krafft,Della-Penna, Pentland, CHI 2018

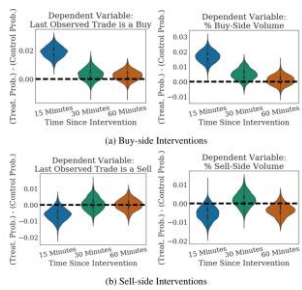
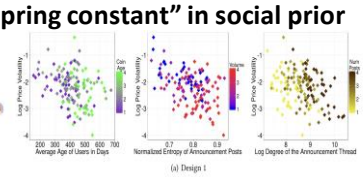
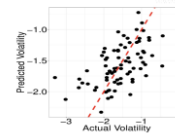


Figure 3: Bootstrap test statistic distributions for two dependent variables as a function of time after our interventions.

adjusting "spring constant" in social prior

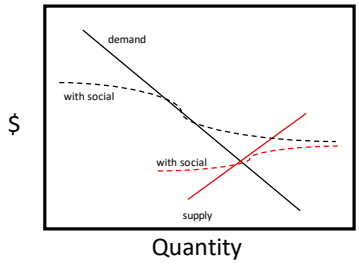


New coin, new users small core group, focused marketing

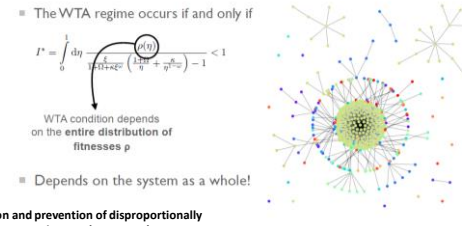


ScamCoins, S* Posters, and the Search for the Next Bitcoin TM: Collective Sensemaking in Cryptocurrency Discussions ACM HCI 2(CSCW):1-28, Nov 2018**

hypothesis:
effect of large social prior on supply-demand

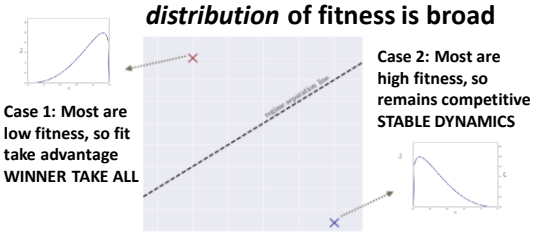


Theorem: in preferential attachment networks, cascade dynamics depend on fitness *distribution*



prediction and prevention of disproportionally dominant agents in complex networks, lera, pentland, sornette *PNAS* 2020

winner-take-all dynamics unless *distribution* of fitness is broad



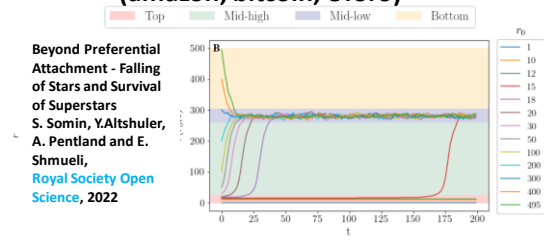
Case 1: Most are low fitness, so fit take advantage WINNER TAKE ALL

Case 2: Most are high fitness, so remains competitive STABLE DYNAMICS

This connects inequality to fundamental welfare theorem

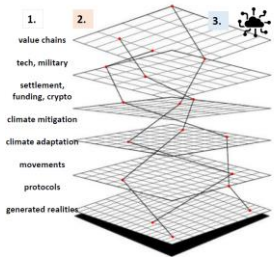
prediction prevention of disproportionally dominant agents complex networks, lera, pentland, sornette *PNAS* 2020

popularity rank vs market dynamics (amazon, bitcoin, eToro)



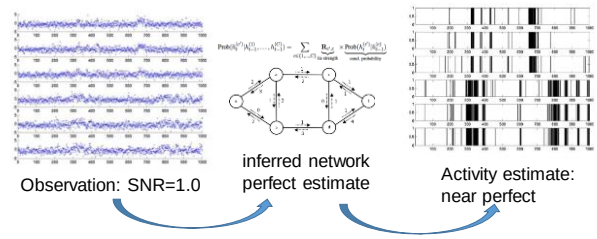
Beyond Preferential Attachment - Falling of Stars and Survival of Superstars S. Somin, Y.Altshuler, A. Pentland and E. Shmueli, Royal Society Open Science, 2022

3. Other networks also influence economics



We would like to begin seeing economic networks as embedded and influenced by a wide range of other networks

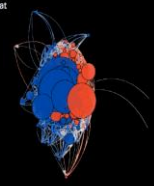
"Causal filtering" for large-scale search



Detection of Coordination Between State-Linked Actors, *Best Paper,* SBP-BRIMS 2022, Erhardt, Pentland

PRC Amplification of Russian Disinformation

Russia-Affiliated Diplomat
PRC-Affiliated Diplomat



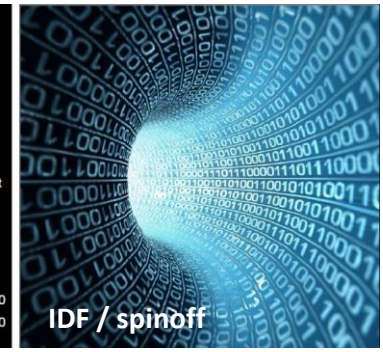
Influence between PRC and Russia diplomat accounts across all topics

- Most engaged with topics: **'Russo-Ukrainian conflict'** and **'2022 Beijing Winter Olympics'**
- Influence and amplification is bidirectional
- Most influential account is **sputnikvaccine** which influences both Russia and PRC-linked accounts

07

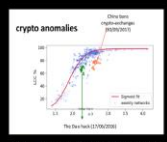
Best Paper, SBP-BRIMS 2022, Erhardt, Pentland

1. Data:
   - Millions of Raw Twitter Tweets
   - A list of 50 known ISIS Twitter accounts given as "sample"
   - Additional 74 known ISIS accounts, kept hidden as test
2. Output:
   - A list of "top 200 accounts most likely to be ISIS members"
   - Runtime: 2 hours
3. Accuracy:
   - 35 new ISIS accounts in top-50
   - 51 new ISIS accounts in top-100
   - 72 new ISIS accounts in top-200



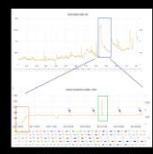
Botnets + Ethereum

Ban on crypto trading in China (September 2017)



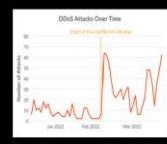
Source: Ongoing work by Shahar Somin and Sandy Pentland

Botnet campaigns in Taiwan (August 2022)

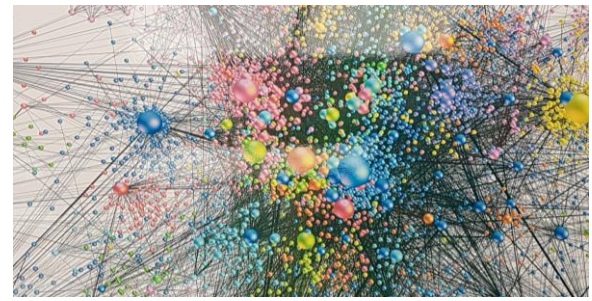


Source: CAIDA Stardust - Time range: 2022-08-11 000000 – 2022-08-13 113702 (UTC)

Darknet activity in Russia & Ukraine (Q1 2022)



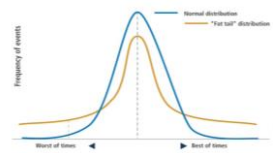
Source: "Ukraine Blames Russia for DDoS Attack on Defense Websites", Data Breach Today



Terrorism Financing – Financial Intelligence Case by Israel @shlomit_wagman

https://wip.mitpress.mit.edu/new-economy

decisions with long-tailed distributions: variance and mean may not be defined

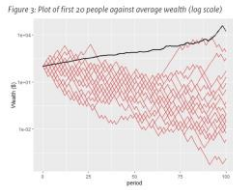


successive samples may appear "normal" but with very different mean and variance

almost all preferential attachment and cascade processes!!!!

non-ergoticity and inequality

example: heads you win 50% of current wealth
tails you lose 40% of current wealth



bad vs good luck

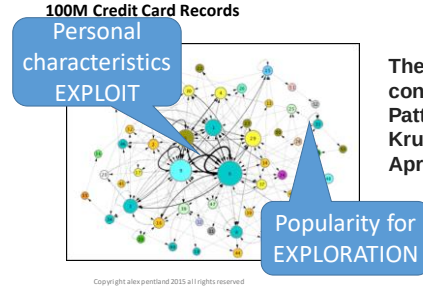
Need many small trials for good performance

Diverse portfolios, Progressive taxation, Social Insurance

https://jasoncollins.blog/2020/01/22/ergodicity-economics-a-primer/

physical communities

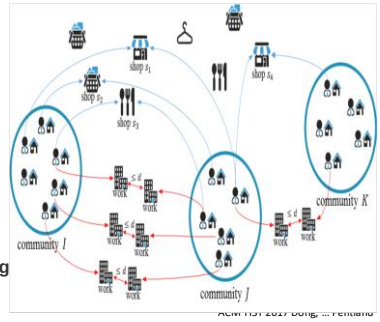
100M Credit Card Records



The predictability of consumer visitation Patterns, Nature Sci Rpt Krumme…Pentland, April 2013

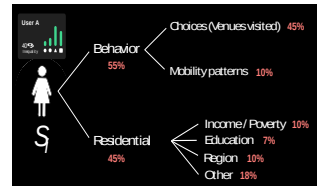
predict behavior 300% better than demographics:
echo chambers through face-to-face social learning

Social Bridges in Urban Purchase Behavior, Dong et al, ACM TIST 2017



ACM TIST 2017 Dong, … Pentland

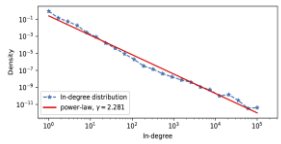
…half of segregation is behavior, not residence



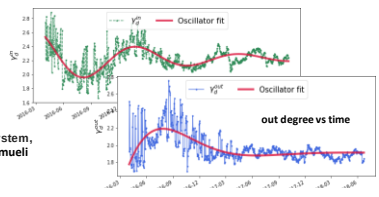
The segregated places of United States cities
E. Moro, D. Calacci, X. Dong, and A. Pentland

The predictability of consumer visitation patterns, Krumme et al, *Nature Scientific Reports* 3, 1645 (2013)

…this segregation of exposure predicts loss of trust, inequality, polarization



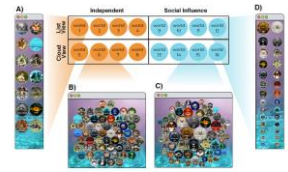
chaotic price history vs stable network structure: in- and out- degree vs time



ETHEREUM

Network Dynamics of a Financial Ecosystem, Somin, Altshuler, Gordon, Pentland & Shmueli *Nature Scientific Reports*, 3/2020

social networks: group preferences grow more diverse



Epstein, Ziv, et al. "Social influence leads to … diverse local trends." Proc. ACM HCI 5.CSCW2 (2021): 1-18.

social influence -> unpredictable winner-take-all market.

emergence of local cultural trends more diverse between than within

analogous to Music Cultural Market experiments