MAT211

A Mathematical Approach to the Spread of Rumours on Social Media

Presented to -

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PRESENTER 1

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Introduction

The Phenomenon:

Rumor spreading is a significant phenomenon in the digital age, especially on social media. It can create profound social, political, and economic consequences, such as:

- Triggering mass panic.
- Damaging reputations.
- Affecting political stability

Introduction

Why Study Rumor Spreading?

- Understanding its dynamics helps develop strategies to minimize negative impacts.
- Promotes safer and healthier online communities.

Role of Mathematical Models:

- Provide a systematic approach to understanding the dynamics.
- Incorporate factors like transmission rates, trust levels, and social network structures.
- Offer predictive insights to design effective intervention strategies.

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Key Concepts

Rumor Spreading as a Dynamic Process:

- Based on epidemiological models used for diseases, particularly the SIR Model (Susceptible, Infected, Recovered).
- Adapted to represent how information (or misinformation) spreads in social networks.

The SIR Model:

- Susceptible (S): Individuals who haven't heard the rumor but can be influenced.
- Infected (I): Those actively spreading the rumor.
- Recovered (R): Individuals who no longer spread the rumor, either because they've lost interest or realize it's false.

Key Concepts

Behavioral Rules in Rumor Dynamics:

- Susceptibles become Infected when exposed to the rumor.
- Infected individuals continue spreading until meeting another Infected or Recovered person, at which point they transition to Recovered.
- The rumor dies out when only Susceptible and Recovered remain.

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Mathematical Model

Model Framework:

- Based on the SIR Model, adapted for rumors:
  - $S(t)$: Number of susceptible individuals at time t.
  - $I(t)$: Number of infected (spreading) individuals at time t.
  - $R(t)$: Number of recovered individuals (no longer spreading) at time t.

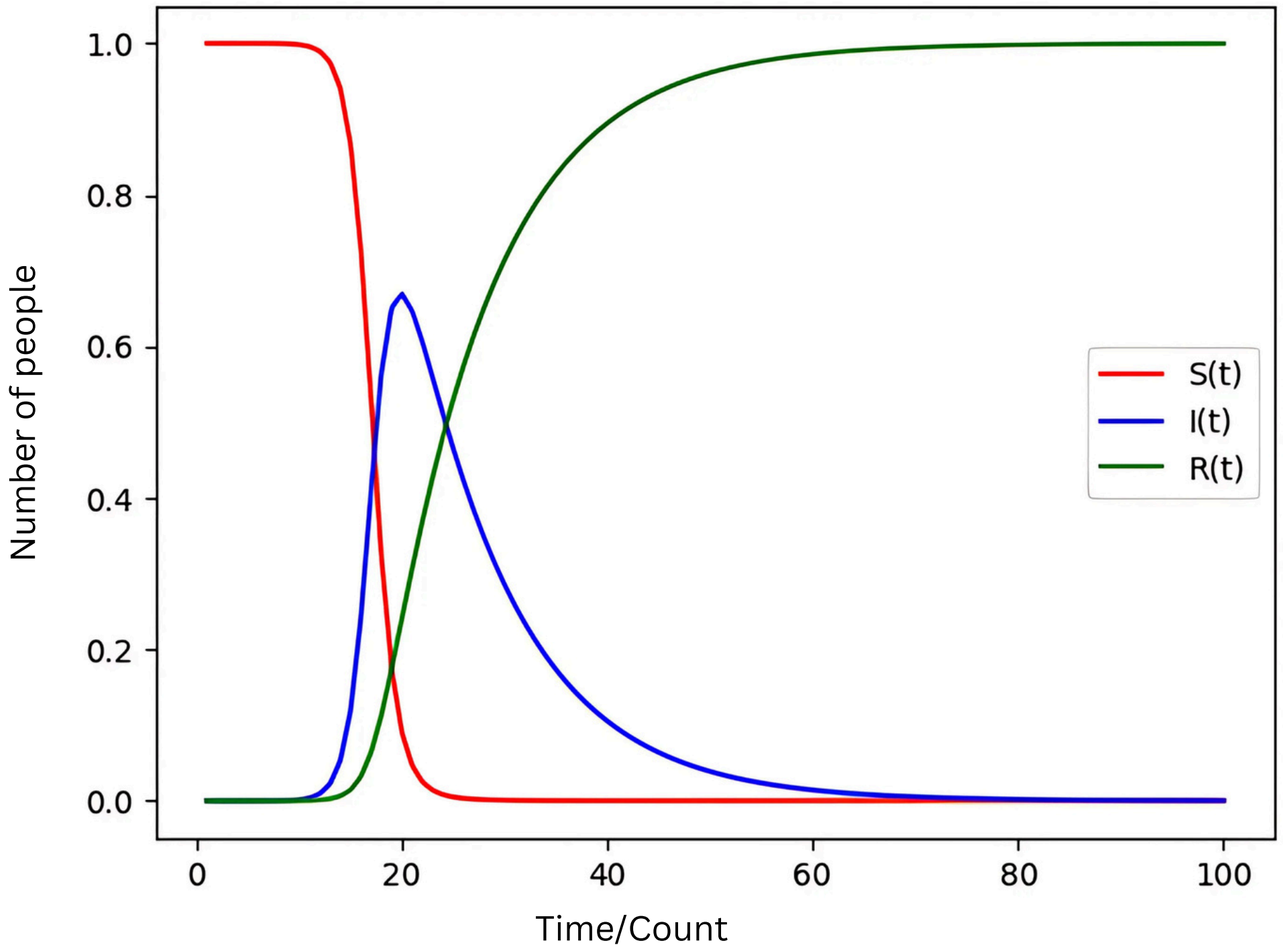
Governing Equations:

- Change in susceptibles: $$\frac{dS}{dt} = -\beta S(t) I(t)$$
- Change in infected individuals: $$\frac{dI}{dt} = \beta S(t) I(t) - \gamma I(t)$$
- Change in recovered individuals: $$\frac{dR}{dt} = \gamma I(t)$$

Parameters:

- β: Transmission rate (probability of spreading the rumor).
- γ: Recovery rate (probability of stopping rumor spreading).

Line Chart



[Credit: Towards AI]

PRESENTER 4

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Numerical Simulation

Simulation Setup

Population: 1,000 individuals.
Initial Values:
$S(0)$=950: Susceptible individuals.
$I(0)$=50: Infected individuals (spreading the rumor).
$R(0)$=0: Recovered individuals.

Parameters:
β=0.003: Rumor transmission rate.
y=0.01: Recovery rate.

Numerical Simulation

For Day 1: Data Calculation

Given:

- β=0.003, γ=0.01, Δt=1 day.
- Initial values: S(0)=950, I(0)=50, R(0)=0.

Compute derivatives at t=1:

$$\frac{dS}{dt} = -\beta S(0)I(0) = -0.003 \cdot 950 \cdot 50 = -142.5$$

$$\frac{dI}{dt} = \beta S(0)I(0) - \gamma I(0) = 0.003 \cdot 950 \cdot 50 - 0.01 \cdot 50 = 142$$

$$\frac{dR}{dt} = \gamma I(0) = 0.01 \cdot 50 = 0.5$$

Numerical Simulation

For Day 1: Data Calculation

Update Values:

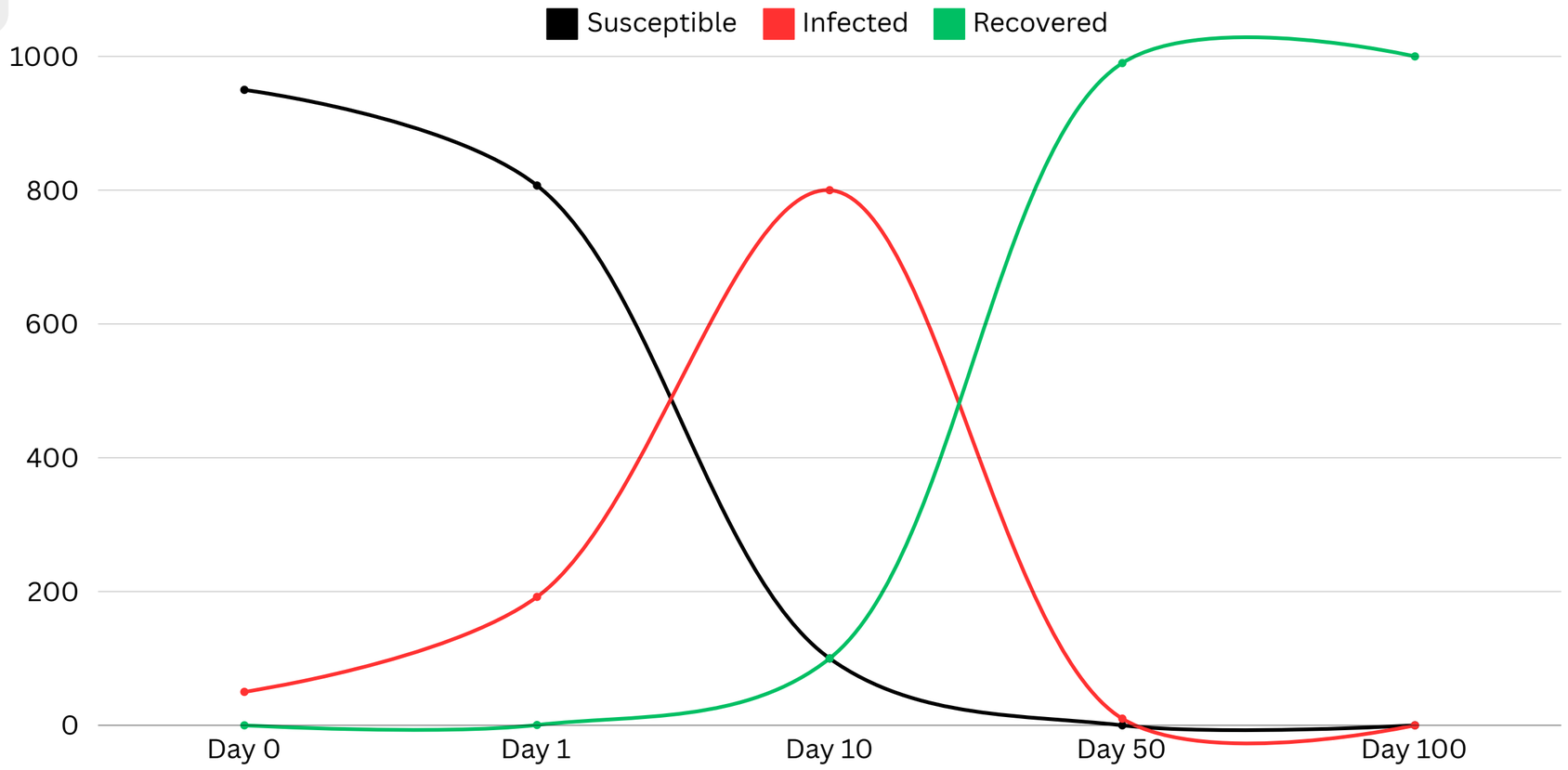
$$S(1) = S(0) + \Delta t \cdot \frac{dS}{dt} = 950 + 1(-142.5) = 807.5$$

$$I(1) = I(0) + \Delta t \cdot \frac{dI}{dt} = 50 + 1 \cdot (142) = 192$$

$$R(1) = R(0) + \Delta t \cdot \frac{dR}{dt} = 0 + 1 \cdot (0.5) = 0.5$$

Numerical Simulation

Line Chart



PRESENTER 5

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Automate with Python

```
import numpy as np
import matplotlib.pyplot as plt

# Parameters
beta = 0.003
gamma = 0.01
N = 1000  # Total population
S = [950]  # Initial susceptible
I = [50]   # Initial infected
R = [0]    # Initial recovered
t = [0]    # Time steps

# Time step and simulation duration
dt = 1  # 1 day
days = 100

# Simulation using Euler's method
for day in range(1, days + 1):
    dS = -beta * S[-1] * I[-1] * dt
    dI = (beta * S[-1] * I[-1] - gamma *
I[-1]) * dt
    dR = gamma * I[-1] * dt

    S.append(S[-1] + dS)
    I.append(I[-1] + dI)
    R.append(R[-1] + dR)
    t.append(day)
```

```
# Plotting the results
plt.plot(t, S, label='Susceptible')
plt.plot(t, I, label='Infected')
plt.plot(t, R, label='Recovered')
plt.xlabel('Days')
plt.ylabel('Population')
plt.title('Rumor Spread Simulation')
plt.legend()
plt.grid()
plt.show()
```

How Rumors Spread on Social Media

Why Social Media?

Platforms like X(Twitter), Facebook, and Instagram allow rumors to spread instantly to millions.

Key Factors in Social Media Rumor Spread:

1. Network Effects:
- Social media connects large groups, making it easy for rumors to travel.
2. Influencers:
- High-followed accounts or viral posts act as "super-spreaders."
3. Algorithms:
- Recommendation systems can prioritize sensational content, boosting rumor visibility.

Controlling Rumors on Social Media

Strategies to Stop Rumors:

1. Promote fact-checking tools.
2. Limit the spread of flagged posts.
3. Educate users on verifying information.
4. Collaborate with governments and tech companies.
5. Penalize repeat offenders of misinformation.

PRESENTER 6

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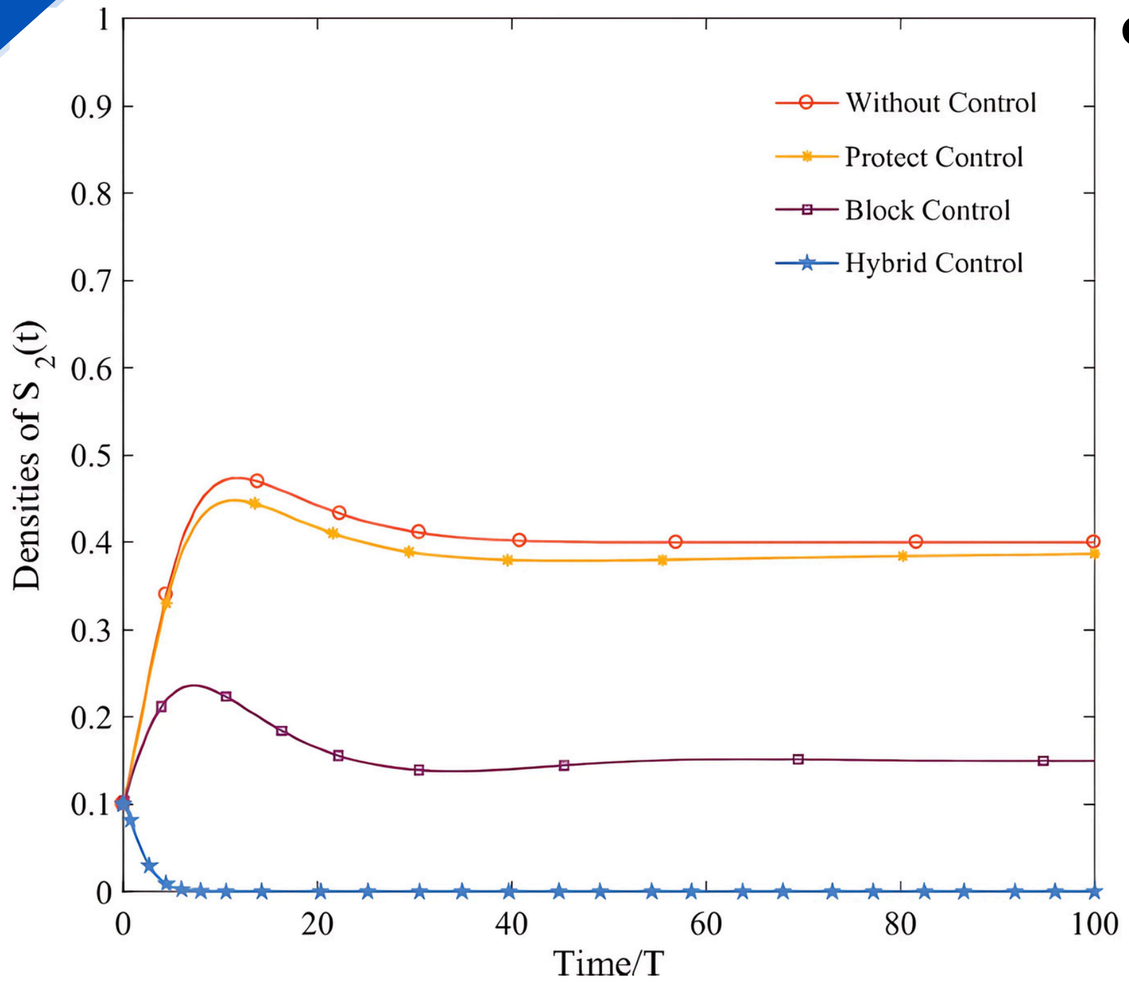
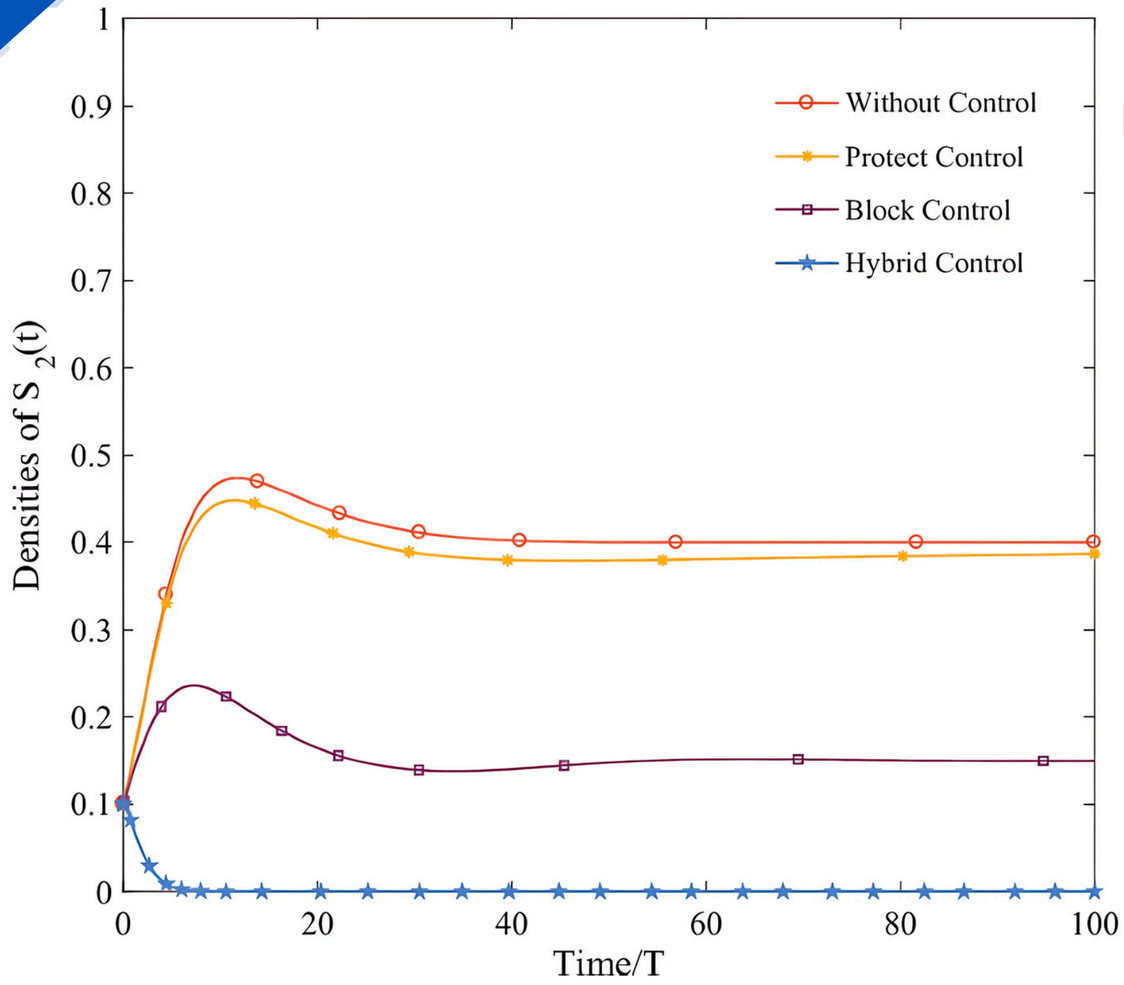
Control Strategies (Graph Analysis)



Control Strategies:

1. Without Control (Red Line):
   - The rumor spreads quickly with no control.
   - A lot of people become susceptible to the rumor in a short time.
2. Protect Control (Orange Line):
   - Some protection is applied to slow down the spread.
   - The number of susceptible people decreases more slowly, meaning the rumor is delayed but still spreads.
3. Block Control (Purple Line):
   - Strong measures completely block the rumor from spreading.
   - Fewer people are exposed to the rumor, and it spreads very slowly.
4. Hybrid Control (Blue Line):
   - A combination of protection and blocking strategies.
   - The rumor spreads the slowest, keeping most people safe from hearing it.

Control Strategies (Graph Analysis)



Key Takeaways:

1. Hybrid Control is the most effective strategy, as it slows the rumor spread the most.
2. Block Control is also effective, but Protect Control only delays the spread without fully stopping it.
3. Without any control, the rumor spreads quickly, affecting many people.

Conclusion

Rumors spread rapidly, especially on social media, but mathematical models like the SIR model help us understand and manage them. By applying strategies such as fact-checking, user education, and limiting the virality of false information, we can reduce their impact. Early detection and intervention remain the most effective ways to control the spread of misinformation.

"Rumors are carried by haters, spread by fools, and accepted by idiots." - Unknown

Thank You

For your attention to this presentation.