Agent-Based Modeling of Cultural Evolution in India

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Objective: The aim of this project is to employ Agent-Based Modeling (ABM) techniques to simulate and analyze cultural evolution. By creating a dynamic and interactive model, we seek to understand the complex and nonlinear dynamics of cultural change, exploring how various factors influence human thinking under certain rules of cultural traits within a population.In this project we will look from the point of view of Religion , conversion of Religion as well as its factors.

Background: Cultural evolution is a multifaceted process influenced by a myriad of interconnected factors, including social interactions, communication patterns, environmental conditions, and individual cognitive processes. Traditional approaches to studying cultural evolution often struggle to capture the intricate dynamics and emergent properties that characterize cultural systems. ABM provides a powerful framework to address these challenges by representing agents as autonomous entities with individual behaviors, interactions, and adaptation mechanisms.

Stakeholder:-

1. **Researchers and Academics:** Scholars specializing in anthropology, sociology, cultural studies, computer science, and related fields have a vested interest in understanding the dynamics of cultural evolution.
2. **Policy Makers:** Governments, non-governmental organizations (NGOs), and international bodies may utilize insights from cultural evolution models to inform policy decisions related to cultural preservation, multiculturalism, education, and social integration.
3. **Educators:** Professionals in the education sector, including teachers, curriculum developers, and educational policymakers, may benefit from insights gained through cultural evolution modeling to

design more effective educational programs that account for diverse cultural backgrounds and dynamics.

4. **Cultural Institutions**: Museums, libraries, heritage sites, and cultural organizations are interested in preserving and promoting cultural heritage. Insights from cultural evolution models can inform strategies for conservation, curation, and interpretation of cultural artifacts and traditions.
5. **Technology Developers**: Developers of digital platforms, social media, and communication technologies may leverage insights from cultural evolution models to design more culturally sensitive and inclusive technologies that foster positive interactions and knowledge exchange across diverse cultural groups.
6. **Community Leaders and Advocates**: Leaders within communities, cultural advocacy groups, and grassroots organizations may utilize findings from cultural evolution models to advocate for the preservation of cultural traditions, address social inequalities, and promote cultural diversity and inclusivity.
7. **General Public**: Members of the general public, including individuals from diverse cultural backgrounds, may benefit from a deeper understanding of cultural dynamics provided by cultural evolution models. This understanding can foster appreciation, tolerance, and empathy towards different cultures, contributing to social cohesion and harmony.

Schema:-

1. **Agent Representation:** Model agents will be individuals within a population, each characterized by unique traits, preferences, and cultural beliefs. Agents will interact with each other, mimicking social exchanges and cultural transmission.

2. **Cultural Traits:** Identify key cultural traits relevant to the study, such as language, beliefs, or any major news regarding their beliefs. These traits will evolve over time through interactions between agents, incorporating mechanisms for innovation, transmission, and adaptation.
3. **Network Structure:** Define the social network through which agents interact. The structure of this network will influence the spread and adoption of cultural traits which . Different network topologies (e.g., small-world, scale-free) will be explored to understand their impact on cultural evolution.
4. **Learning and Adaptation:** Implement cognitive processes that allow agents to learn from their experiences and adapt their behaviors accordingly. This may include mechanisms for social learning, individual innovation, and selective adoption of cultural traits.
5. **Environmental Factors:** Integrate environmental variables that can affect cultural evolution. This may include external events, resource availability, or geographic factors, providing a more holistic view of the dynamics involved.
6. **Simulation and Analysis:** Run simulations to observe the emergent patterns and dynamics of cultural evolution. Analyze the results to identify trends, tipping points, and the role of specific factors in shaping cultural change.

We can also use the above schema with same data about changes in culture over past years which can help us to find the range of the changes in culture over time in regards to different events in that time period which can helps us identify a relation between the changes in belief over time and how it affected the culture . Applying the appropriate technique (or a set of techniques) to analyze a model's behavior and parameter sensitivity is the key to validating and predicting any real-world phenomena in an agent-based model. We demonstrate the application of various exploratory data analysis, sensitivity analysis, and data mining techniques to understand the impact of various input parameters on the model output.

Technical Requirements:-

1. **Programming Language:** Choose a suitable programming language for implementing the ABM.
2. **Simulation Environment:** Select or develop a simulation environment that provides the necessary infrastructure for defining agents, their behaviors, interactions, and the environment in which they operate. This environment should allow for easy manipulation of parameters and observation of simulation outcomes.
3. **Agent Definition:** Define the characteristics, behaviors, and decision-making mechanisms of individual agents within the model. Agents should be able to interact with each other and their environment based on predefined rules or algorithms.
4. **Cultural Trait Representation:** Establish a framework for representing cultural traits within the model. This includes defining the traits themselves, their attributes, and the mechanisms governing their transmission, adoption, and modification over time.
5. **Network Structure:** Specify the network structure through which agents interact and exchange cultural information. This could be a regular lattice, random graph, small-world network, or any other topology that reflects real-world social networks.
6. **Learning and Adaptation Mechanisms:** Implement learning and adaptation mechanisms that enable agents to acquire, modify, and transmit cultural traits based on their experiences, interactions with others, and environmental feedback.

7. **Data Input and Output:** Develop mechanisms for inputting initial conditions, parameters, and external data into the model, as well as for outputting simulation results for analysis and visualization. This could include reading data from files, databases, or APIs, and generating output reports, graphs, or animations.

Literature Review

Research Question- " How can Agent-Based Modeling help to know about Cultural Evolution over time ?"

Scope and its importance -Agent-based model will play a major role in studying cultural evolution and its dynamics

1. **Understanding Cultural Change:** Investigate how and why cultures evolve, including the mechanisms behind the evolution as well as the changes of culture with their beliefs.

2. **Cultural Variation:** Analyze the changes of cultures across different regions, and social groups, exploring both the commonalities and unique characteristics of various cultural systems.

3. **Cultural Transmission:** Examine the processes by which cultural information spreads within and between populations, including the roles of imitation, teaching, language, and media.

4. **Cultural Adaptation:** Explore how cultures adapt to environmental, technological, economic, and social changes, including the evolution of norms, values, and institutions.

5. **Cultural Dynamics:** Investigate the dynamics of cultural change, including the role of cultural inertia, feedback loops, and tipping points in driving shifts in cultural practices and beliefs.

6. **Applied Implications:** Explore the practical implications of cultural evolution research for areas such as public policy, education, marketing, and conflict resolution.

7. **Interdisciplinary Perspectives:** Integrate insights from anthropology, psychology, sociology, biology, economics, and other disciplines to gain a comprehensive understanding of cultural evolution and its dynamics.

8. **Long-Term Trends:** Investigate long-term patterns and trends in cultural evolution, including the rise and fall of civilizations, cultural convergence and divergence, and the spread of globalization

Introduction-

The goal of research in cultural evolution is to understand and explain cultural change at several causal levels. Culture, like many scientific objectives, is complex. Multiple processes interact at a wide range of spatial and temporal levels. This is reflected in the many definitions of culture, some of which selectively emphasize features and processes of culture and cultural change (Heidi Colleran and Ruth Mace) as well as in the broad range of methods used to deconstruct and analyze the component causal processes of cultural change. While there is some disagreement among these attempts to describe and explain human culture, there is a general consensus that culture is made up of several different elements (or traits) that these traits are related to each other and that they are implemented in overlapping but heterogeneous ways by various populations around the world.

That culture is composed of several particular traits (or characteristics), and these traits bear shifting connections to one another, which these characteristics are figured out in covering however heterogeneous ways by different populaces within the world.

The traits agents acquire can change how they learn, modulating the overall behavior of the population in which they are a part. At the same time, the aggregate behavior of the population can influence the availability and valence of such traits. The Agent model approach thus highlights how individual (micro) and population (macro) levels can influence one another through effects on trait relationships and availability.

A second important upshot is that a systems approach allows for the modeling of processes of path dependence and self-organization. The agent-based models we adopt here provide us with the pattern of individual agents that interact within an environment. Agents have autonomous behavior and can follow predefined rules or adapt based on their environment and interactions with other agents.

Of course, the nature and effects of trait interrelations themselves may change over time. Shifts in preferences and beliefs are particularly noteworthy, as these both govern behavior and change constantly in the face of exposure to new evidence and ideas. In our modeling framework, preferences could be modeled with a positive attribute and non-preferences with a negative attribute.

Cultural systems may also help to explain the emergence of cultural groups. A single trait may suffice to distinguish between members of different groups. Yet for the existence of such group-defining traits to be a causal factor influencing the behavior of others—for instance, to serve as a signal for intra-group and inter-group biases or overt prejudice towards other groups—and for the existence of the trait to be formed and maintained, such a trait needs to be interdependent with those that induce the relevant behavior.

There are numerous examples of how important groups are for dispersal of ideas about the world and our behaviours towards other people, and how easily they form.

Evolutionary trajectories and historical dependencies-

At this point, it is helpful to distinguish between *origin explanations* and *distribution explanations*. Origin explanations, which aim at explaining how a particular trait came about, often by pointing to studies in palaeoanthropology, developmental and experimental psychology, and cognitive neuroscience that lay out the evolutionary and developmental circumstances required for certain capacities to come about. Distribution explanations, by contrast, explain the distribution of traits in a population, or across populations.

Yet traits might also be modulated through *indirect filtering*, for instance, where such filters determine with whom one associates.With such a filter, the traits one acquires will be skewed by the model one is oriented towards. Another indirect filter is a *similarity filter*, where individuals associate with others who bear similar traits (sometimes called *homophily*), either through deliberate choice of association, or by pruning their social networks of individuals with dissimilar traits

Relationships between traits can also lead to more complex and diverse cumulative culture, beyond the trivial accumulation of making culture larger by adding independent elements to a collection of traits,

Cumulative culture is likely to significantly contribute to path dependence in cultural evolution. When traits are preserved and built upon past innovations, culture generates *traditions*—historical chains of cultural variants linked through patterns of cultural transmission. Cultural evolutionary researchers often use the metaphor of a 'ratchet' to describe this historical process, since like a ratchet, things move steadily in a single direction—changes are kept, 'ratcheted', into the future rather than 'slipping back' over multiple transmission events (Lewis G. Dean). This ratcheting metaphor is meant to capture the way that cumulative culture differs from a range of possible (cultural) evolutionary scenarios—for instance, where evolution occurs stochastically, moves cyclically through a range of variants, or merely tracks environmental features in ways that do not involve building upon priorly held cultural variation. In so doing, cumulative culture can explain the production of climate-appropriate clothing social organizations and institutions . Because cumulative culture produces traditions where future states of the tradition depend on the past states of that tradition, it is the kind of process that generates path dependence

Yet it is not only *which* traits are acquired that determines which cultural states are accessible, but also the *sequences* of events can determine which traits can coexist. Let the traits B and C be dependent on A, and B be compatible with C but inhibit A. The two traits B and C can then be maintained simultaneously, in the same system, provided that B is acquired first. If, on the contrary, C is acquired first, then there are no traits allowing for the acquisition of B. As an example, A may be a generic or non-explanatory answer to a politically charged issue, B a populist answer, and C a complex answer providing a real explanation. B could then be attractive enough not to be lost in a population even in face of a real answer, and even if it would not appear if there already existed such an answer, while C could easily replace the unsatisfactory answer A. The importance of the sequence of acquisition is further amplified if B and C enable different clusters of traits down the line.

Methodologies

To develop an agent-based model for cultural evolution, it is important to consider various methodologies. These methodologies can help researchers understand and simulate the complex dynamics of cultural evolution. Some methodologies for agent-based modeling in cultural evolution include:

- A bottom-up approach where individual agents are given specific rules and behaviors that dictate how they interact with each other and their environment. These rules can be based on theories of cultural transmission, such as social learning, cultural evolution, and memetics. By simulating the interactions between agents over time, researchers can observe how cultural traits spread and evolve within a population.
- Another approach is to use a top-down approach, where researchers start with macro-level patterns and then work backward to understand the individual-level processes that give rise to them. This approach can be useful for studying large-scale cultural phenomena.

Another approach can be to use Agent Based model to try to simulate environment like a real world and use agent as people to interact with each other which in fact is the concept of Agent Based model but in the environment we will need to introduce people from different cultural background with same people having different trait and same similar trait such as belief , caste , gender, etc .

Here we will also need to introduce interaction between the agents and how they might react some steps for the outcome for an agent after interaction are:-

Assessment of Interaction Outcome: After the interaction, the agent assesses the outcome based on its objectives, preferences, and the information it received during the interaction. This assessment could involve evaluating whether the interaction was beneficial, neutral, or detrimental to its goals or well-being.

Updating Internal State: The agent updates its internal state based on the information acquired during the interaction. This may involve revising beliefs, preferences, or behavioral strategies in response to new information or experiences gained from the interaction.

Adaptation and Learning: If the interaction leads to a desirable outcome, the agent may reinforce the behaviors or strategies that contributed to the positive outcome through learning mechanisms such as reinforcement learning or social learning. Conversely, if the outcome is unfavorable, the agent may adjust its behavior to avoid similar outcomes in the future.

Decision Making: Based on the assessment of the interaction outcome and its updated internal state, the agent makes decisions about its future actions. These decisions could include whether to continue interacting with the same agent, seek out new interactions, modify its behavior, or maintain the status quo.

Social Influence: The agent may be influenced by the behaviors, beliefs, or preferences of the interacting agent, particularly if it perceives the interacting agent as credible, trustworthy, or influential. This social influence can shape the agent's subsequent actions and decisions.

Interaction with Environment: Depending on the ABM's design, the agent may also interact with its environment following the interaction with another agent. This could involve further actions such as resource acquisition, movement, or engaging in additional interactions with other agents or elements of the environment.

Overall, an agent's reaction after an interaction in an ABM is determined by a combination of its internal state, the outcome of the interaction, its learning mechanisms, and the rules governing its behavior within the model. These reactions contribute to the dynamic evolution of the system as agents interact and adapt to their environment and each other over time.

But we can't say that the agent will have 100% positive influence or Negative influence so for this we will have a probability for both positive and negative influence on the agents, this will tell us the chances of trait A to get influenced by trait B and vice versa.

To get the probability and use it , we will need the help of the following steps:-

Data Collection: Gather past data on cultural interactions or phenomena relevant to your model. This could include data on social interactions, cultural diffusion, information spreading, or any other relevant aspect of cultural evolution. Ensure that the data is well-documented and represents the phenomena you're interested in modeling.

Feature Extraction: Identify the key features or variables from the past data that are relevant to determining the probability of influence. This could include factors such as the characteristics of interacting agents, the context of interactions, the duration or intensity of interactions, and any other factors that may influence the likelihood of influence.

Interaction Rules: Based on the characteristics extracted from your previous data set, identify how these characteristics affect the likelihood of influence in the model. For instance, you could assume that agents with similar characteristics have a higher likelihood of influencing one another, or that more frequent interactions increase the likelihood of influence.

Quantify Influence Factors: Assign weights or probabilities to each of the variables recognized in your include extraction handle. These weights speak to the quality of impact that each figure has on the in general likelihood of impact. You might assign these weights based on space information, master judgment, or factual investigation of past information.

Combine Influence Factors: Develop a method for combining the influence factors to calculate the overall probability of influence in a given interaction. This could involve simple rules, such as taking a weighted sum of the factors, or more complex mathematical functions.

Validate Model Assumptions: Validate the assumptions underlying your model by comparing the predicted probabilities of influence to observed probabilities in the past data. This can help ensure that your model accurately captures the relationships between the features and the probability of influence.

Iterate and Refine: Iterate on your model, refining the interaction rules and influence factors based on feedback from validation and additional analysis. This might involve adjusting weights, incorporating additional features, or refining the mathematical functions used to combine influence factors.

Stability versus change

Empirical perceptions of social phenomena reveal broad variation in the rate at which culture changes. These rates can extend from characteristics and frameworks that stay more or less the same over numerous eras, to characteristics and frameworks that alter quickly inside a single era. For occasion, there are many illustrations of religious beliefs and social standards that have remained comparable over long periods of time but at the same time many changes have moreover happened.

A number of clarifications have been recommended for the variety in the rate of change in social advancement, counting outside factors such as the physical and environmental environment (Robert A. Foley), demographic componentand cultural complexity (Wybo Houkes and Adrien Querbes). Here, we investigate how trait relationships and frameworks of culture may clarify variety within the pace of social alter. Two components appear critical to consider. One is the inherent properties of characteristics that decide their connections with other characteristics, and the other is sifting forms which will support collections of characteristics that either advance steadiness or drive alter. We first consider characteristic connections that can advance solidness and after that connections that can drive changes. We conclude with portraying frameworks with designs or fad-like flow, in which traits may alter more rapidly than when they are displayed as autonomous characteristics. Here we'll be utilizing Agent Based model to demonstrate in which a environment and operator as human being with attributes will be characterized and their interaction will be utilized to see the changes in culture.

It could be a conceivable expansion of the thought that traits are more or less consistent with one another that characteristics which commonly bolster each other's transmission could shape stable cultural clusters that are kept up over many generations.

As one can see, the steadiness of social systems—or as is more likely to be the case, particular characteristic assemblages—is conceivably advanced both by shared connections among its parts, and possibly by contradictory connections with characteristics not part of the framework. This portrays one kind of evolutionary history; here, characteristic gatherings successively increase inside compatibility and diminish external compatibility. In case such highlights were to characterize most characteristics of a social system, then one would anticipate such a system to inevitably enter a bowl of fascination where small consequent alter could occur. However, as we are going see, there are also circumstances and arrangements of characteristic connections that advance alter.

Whereas shared back can deliver rise to steady cultural systems, other relationship conveyances will advance alter instead of stability. Some courses of action may even provide rise to rates of change that are higher than for freely evolving traits. One sort of trait relationship that would promote alter or maybe than stability is an asymmetric relationship between two characteristics:

For instance, trait A may encourage the procurement of a trait B while B has the inverse impact on A (hindering its procurement). Such a topsy-turvy relationship seem to lead to a progression of trait substitution occasions. If A appears to begin with, at that point it'll promote B, but when B becomes common, it'll cause A to vanish. The processes are specifically subordinate on properties of the current cultural system and can lead to a quickening generation of unused cultural traits.

Simulation model

In the simulations, there is a universe of cultural traits with relationships between them. At the outset, the agents provided traits at random from a group of traits .

The agents meet in random interactions. One round of interactions, or a time step, includes copying, invention and a birth death process.

First, each agent, the receiver, samples one other agent as a cultural model. The model randomly selects one of the traits, i, in its repertoire for display to the receiver.

The receiver copies the trait with a probability determined by the total influence all parameters have on him, which indicate how likely he is to copy the trait .

Key finding

- Cultural traits in societies that face rapid environmental or social changes have a higher rate of change compared to societies in stable environments.
- Once exposed to globalization forces, traditional societies are likely to adapt, transform, or disappear rather than remain unchanged. This gives basis for the prediction that the rate of change of any cultural trait should be higher for societies that face rapid environmental or social changes than for societies that evolve in relatively stable environments.
- It is just predictable that once they get exposed to globalization forces, bodies of TEK remaining in indigenous, peasant, and other types of semi-autarkic societies are bound to either change and adapt or disappear.
- That societies experiencing rapid environmental or social changes have a higher rate of change in their cultural traits compared to societies in stable environments. This finding suggests that cultural evolution is influenced by external factors such as globalization and environmental changes. This finding suggests that cultural evolution is influenced by external factors such as globalization and environmental changes
- ABMs highlight the significance of way reliance in social advancement, where verifiable occasions and chance events shape the

direction of social alter. Little beginning contrasts or irregular occasions can lead to unique social directions over time.

- ABMs illustrate the effect of social systems on social flow, showing how arranged structure influences the dissemination of social characteristics and the arrangement of social clusters or communities.
- ABMs shed light on the part of development in social advancement, appearing how novel thoughts or behaviors can spread through a populace and gotten to be consolidated into the social collection. These models moreover investigate components that advance or restrain advancement, such as social learning components and natural weights.
- ABMs explore how social characteristics advance in reaction to changing natural conditions, social elements, and specific weights. These models show how social advancement can lead to the adjustment of populaces to their environment and the co-evolution of culture and science.

GAPs-

- Research on cultural evolution using agent-based models has made significant progress in understanding how cultural traits spread and evolve within populations. However, there are still some gaps in this research that need to be addressed.
- cultural evolution agent-based models is the limited representation of multiple interrelated traits. Many existing models tend to focus on a small number of traits or overlook the relationships between different cultural traits.
- This limitation hinders our ability to capture the complex dynamics that arise from the interaction and interdependency of multiple traits. By not representing multiple interrelated traits, current research in cultural

evolution agent-based models may overlook the influence of trait interactions on the evolution and spread of cultural phenomena.

- cultural evolution agent-based models is the limited consideration of external forces and environmental factors that can influence cultural change. While some models consider the internal forces of assimilation and diffusion, there is a lack of exploration into the impact of rapid environmental or social changes on cultural change. This gives basis for the prediction that the rate of change of any cultural trait should be higher for societies that face rapid environmental or social changes than for societies that evolve in relatively stable environments.
- Existing research on cultural evolution agent-based models often lacks a comprehensive understanding of how cultural diversity is maintained or diminished over time. Strategies to protect biological and cultural diversity that strive to maintain traditional societies and related knowledge systems as they were in the past are bound to fail.
- cultural evolution agent-based models is the limited consideration of the role of cultural transmission mechanisms. Existing models in cultural evolution often do not adequately incorporate the complexity of cultural transmission mechanisms. This gap hampers our understanding of how cultural traits are acquired and spread within populations.

Algorithm

Problem statement-

Cultural evolution, the process by which cultural traits, behaviors, and norms change over time within a population, is a complex phenomenoninfluenced by various factors including social interactions, transmissionmechanisms, and environmental conditions. Understanding the dynamics of cultural evolution is crucial for disciplines such as anthropology, sociology, and economics. Agent-based modeling offers a powerful tool to explore and simulate the dynamics of cultural evolution within populations.here we will take a group of agents with different traits and let them interact with each other and find the outcome

Goals-

1. Explore how cultural traits emerge, spread, and evolve within a population through social interactions and transmission mechanisms.
2. Investigate the impact of factors such as social networks, cultural diversity, and environmental changes on the dynamics of cultural evolution.
3. Examine the emergence of cultural patterns, norms, and institutions over time and their persistence or change in response to external influences.

Inputs for the system (Parameters and Factors)

1. **Population Size**: The total number of agents (individuals) in the simulated population.
2. **Initial Cultural Traits**: The initial set of cultural traits or beliefs possessed by each agent at the start of the simulation.

3. **Social Network Structure**: Parameters defining the structure of social connections between agents, such as random, small-world, scale-free, or custom-defined networks.
4. **Transmission Rate**: The rate at which cultural traits are transmitted between agents through social interactions or imitation mechanisms.
5. **Geographical Constraints**: Parameters defining the spatial layout of the simulated environment, if applicable, which could affect interactions and diffusion of cultural traits.
6. **Agent Behavior Rules**: Rules governing agent behavior, such as decision-making processes, social learning strategies, or adaptation mechanisms.
7. **Simulation Duration**: The duration of the simulation, measured in time steps or iterations.
8. **Data Collection Frequency**: The frequency at which data or statistics are collected during the simulation for analysis.
9. **Trait pool** : Trait pool from which the traits will assigned to the agent randomly
10. **Traits** : we will select 5 traits for the model :-

Religious Beliefs: Beliefs and practices related to religion or spirituality.

- **Language**: Different languages or dialects spoken by individuals in the population.
- **Economic situation** : The distribution of income levels among individuals or households, which can influence lifestyle, consumption patterns, and social status.
- **Clothing and Fashion**: Styles of dress, attire, or adornment associated with particular cultures or subcultures.
- **Cultural Values:** Core values, principles, or ideals upheld by individuals or communities.

Modeling Techniques-

Agent Based Modelling- Agent-basedmodeling is a computational method for simulating the actions and interactionsof autonomous agents within a system. An agent is an autonomous "entity" that can sense its environment, including other agents, and use this information in making decisions. Agents have attributes and a set of basic if/then rules that determine their behaviors. They may also learn (gain a better understanding of the status of other agents and their environment) and adapt their behaviors (change their decision rules) over time, which will require them to have some form of memory.

Agents ;The fundamental building blocks of an Agent Based Model. They are individual entities with specific properties and behaviors. Agent having 6 trait and interact with each other to influence each other on certain rules .

Agent Properties-

- **Religious Beliefs**- Beliefs and practices related to religion or spirituality.
- **Language**-Different languages or dialects spoken by individuals in the population..
- **Language2** - interested language of the agent
- **Economic situation-** lower , middle or upper class in society
- **Thinking** -two types like modern and traditional , traditional are those who are not easily influenced and have firm beliefs in there religion while modern are the opposite of traditional they dont have firm belief and are easily influenced.

- **Age group -** different age group have difference in getting influenced like 16-22 are easily influenced while people of older age are least likely to be influenced .

Agent Behaviors-

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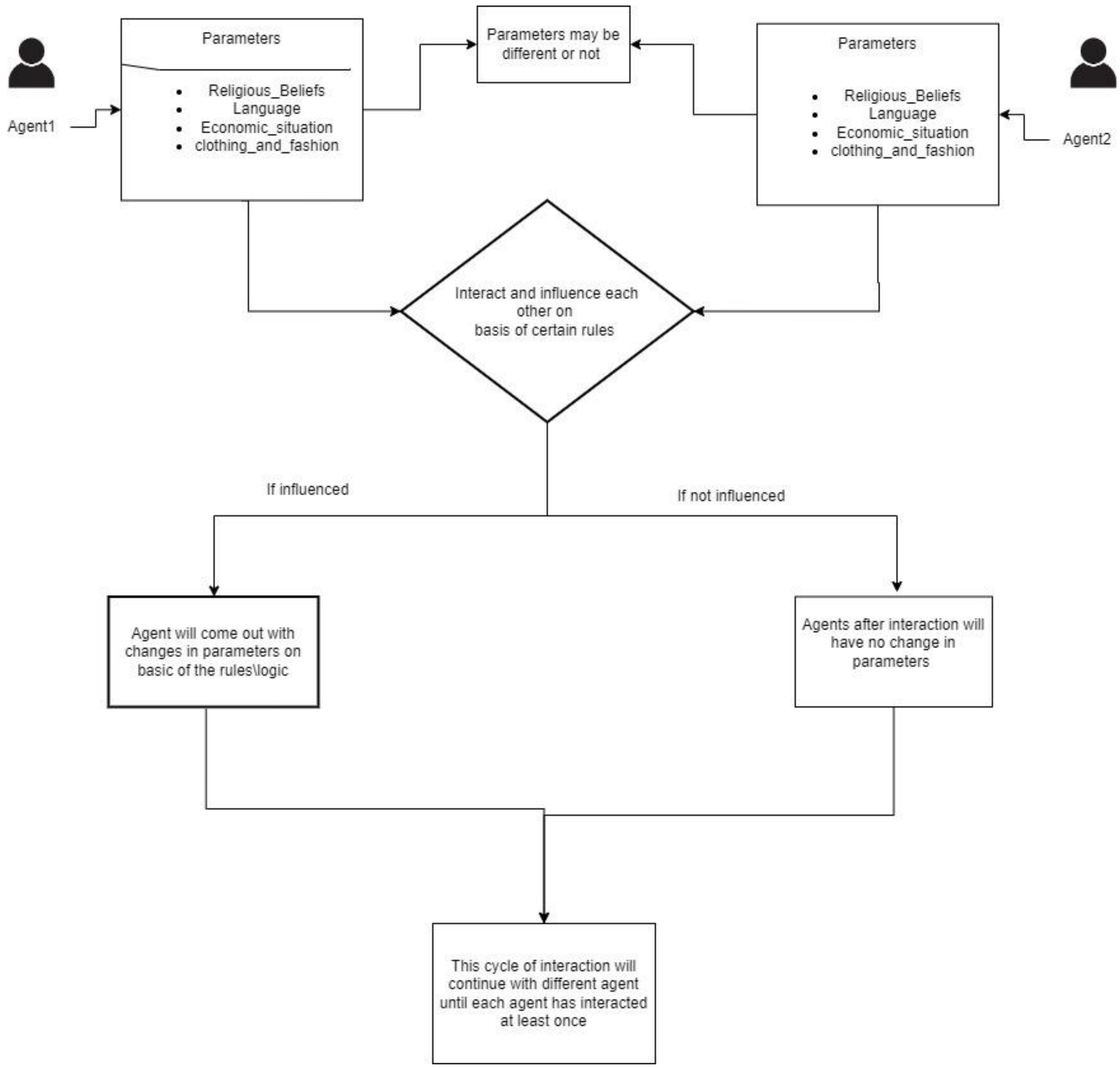
- Trait getting changed by getting influenced by other agent
- Creating a new trait by combination of 2 existing trait
- Getting influenced on basis of certain rules

The Environment-

The environment for the simulation will be a random choice like there will be n no of agent for example 100 agents and 500 trait they will interact with each other on random basis and the changes of influenced will also be random in a certain range and after the interaction is done atleast by every agent once then the new data will be given and we will compare the new data to the original data.

Conceptual Model-



Steps -

- Define a function initialize_agents() to assign initial random values to each agent's attributes such as position (x, y), religious beliefs, language1,language2, economic situation, thinking style, and age group.
- For each agent, generate random values for these attributes within specified ranges.

- Define a function move_agents() to randomly move agents within a grid.
- For each agent, select a random direction (up, down, left, right) and move within the grid accordingly.
- Define a function update_traits() to update agents' traits based on certain influences.
- Determine the chance of influence based on factors such as language, age group, thinking style, and economic situation.
- Calculate total chance of influence and apply it if there's a chance.
- If the language2 of an agent matches with another agent's language1, exchange their religious beliefs based on the calculated chance.
- Define a function print_agents_csv() to print the agents' data to a CSV file at each time step.
- Open a file with a filename including the current time step.
- Write headers and agent data (index, position, traits) to the file.
- In the main() function:
- Seed the random number generator.
- Initialize an array of agents.
- Call initialize_agents() to set initial agent attributes.
- Print initial agent data.
- Iterate over a number of time steps:
- Move agents.
- Update agents' traits.
- Print agents' data for the current time step.

Tools and Techniques

<u>Agent Based Modeling</u>

- Agent based modeling focuses on individual entities called "Agents" that represent the building blocks of the system. The agents are the real people here .
- Each people agent has its own properties (like Religion, language, age, economic condition , thinking) and behaviors (like movement, influencing , conversion). These behaviors are defined by the code written within the behavior section.
- The overall behavior of the Agent come from interacting randomly with each other and influencing each on a certain probability .

<u>Example-</u>

- Suppose there are two people agents, A and B, both are having some differences .Here's how ABM principles play out:
- Properties- A might be of different religion and speak different language than B . B might have modern thinking and belongs to a poor economic background.
- Behaviors- Both agents might move randomly withing the simulated space .
- Interaction- If A and B interact there are chances of both A nad B influencing each other based on the defined rules.
- Emergent Behavior- Over time, an agent may change its properties under influencing from a different agent .

<u>Benefits of Agent Based Modeling-</u>

- Dynamics- ABM allows to model the behavior of individual person and their interactions, providing a view of one person influencing other person to change its religion or languae or any other of the defined properties .
- Flexibility- You can easily adjust agent properties and movement patterns to explore different scenarios and understand how these factors influence cultural changes and helps in cultural evolution .

Probability and statistics-

1. **Agent interaction as Probabilistics Event-** when a agent interact with each other the chances of influencing are considered as a probaboity of influencing by checking ho many people have in influenced in relat world into changing their religion.
2. **Randomness in Movement as well as providing properties to agents-** We are using the random function to introduce randomness in agent movement as well as to choice different properties of a agent as many combination of different combination might be required .
3. **Data Collection and Analysis**- In tracking the number of agents influenced and which changed their religion , we are collecting data that can be analyzed using statistical methods.

Data Analysis

- **Data Collection-**
- Influenced - track the number of agents at each time step. This represents the influenced agents .
- **Exploratory Data Analysis-**
- Plot influenced vs age-group- create a line graph showing the total number of agents on the y-axis and age group on x axis.
- Plot influenced vs thinking - create a line graph showing the total number of agents on the y-axis and thinking on x axis..
- Observe the overall pattern.

Methodology

- A bottom-up approach where individual agents are given specific rules and behaviors that dictate how they interact with each other and their environment. These rules can be based on theories of cultural transmission, such as Religion , Thinking and other aspects. By simulating the interactions between agents over time, we can observe how cultural traits spread and evolve within a population.

Code

```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>


#define POPULATION_SIZE 100 // population size

#define GRID_SIZE 10


typedef struct {

    int x;

    int y;

    int religious_beliefs;

    int language1;

    int language2;

    int economic_situation;

    int thinking;

    int age_group;

} Agent;


//
religion[]={"Hinduism","sikhism","Islam","Christianity","jainism","B
uddhism"} is represented by [0,1,2,3,4,5]

 //languages[]={"Hindi", "Bengali", "Telugu", "Marathi", "Tamil",
"Urdu", "Gujarati", "Kannada", "Odia",
"Malayalam","Punjabi","English","sinhala"} is represented by
[0,1,2,3,4,5,6,7,8,9,10,11,12]
```

```
 // economic[]={"lower class","lower-middle class","middle
class","upper middle class","upper class"} is represented by
[0,1,2,3,4]
 //Thinking[]={"modern","traditional"}; is represented by [0,1]
 //age-group[]={"0-10","11-16","17-22","22-28","29+"} is represented
by [0,1,2,3,4]

void initialize_agents(Agent agents[]);
void move_agents(Agent agents[]);
void update_traits(Agent agents[]);
void print_grid(Agent agents[]);

void initialize_agents(Agent agents[]) {
    for (int i = 0; i < POPULATION_SIZE; i++) {
        agents[i].x = rand() % GRID_SIZE;
        agents[i].y = rand() % GRID_SIZE;
        agents[i].religious_beliefs = rand() % 6;
        agents[i].language2 = rand() % 13;
        agents[i].economic_situation = rand() % 5;
        agents[i].thinking = rand() % 2;
        agents[i].age_group = rand() % 5;
    switch(agents[i].religious_beliefs) {
            case 0:
                agents[i].language1 = 0;
                break;
            case 1:
                agents[i].language1= 10;
                break;
            case 2:
                agents[i].language1 = 5;
```

```
                break;
            case 3:
                agents[i].language1 = 11;
                break;
            case 4:
                agents[i].language1 = 6;
                break;
            case 5:
                agents[i].language1 = 12;
                break;
            default:
                agents[i].language1 = 0;
                break;
        }
}
}

void move_agents(Agent agents[]) {
    for (int i = 0; i < POPULATION_SIZE; i++) {
        // Select a random agent for interaction
        int agent_index = rand() % POPULATION_SIZE;
        int dx = rand() % 3 - 1;
        int dy = rand() % 3 - 1;
        agents[agent_index].x = (agents[agent_index].x + dx +
GRID_SIZE) % GRID_SIZE;
        agents[agent_index].y = (agents[agent_index].y + dy +
GRID_SIZE) % GRID_SIZE;
    }
}
```

```
void update_traits(Agent agents[]) {
    // Define the influence percentages based on different factors
    float language_influence = 0.15;  // 15% influence based on
language
    float age_group_influence = 0.1; // 10% influence based on age
group
    float thinking_influence = 0.1;  // 10% influence based on
thinking style
    float economic_influence = 0.25; // 25% influence based on
economic condition

    for (int i = 0; i < POPULATION_SIZE; i++) {
        // Determine the chance of influence based on language
        float language_chance = 0.0;
        if (agents[i].language1 != agents[i].language2) {
            language_chance = language_influence;
        }

        // Determine the chance of influence based on age group
        float age_group_chance = 0.0;
        if (agents[i].age_group == 0) { //age group 0-10
            age_group_chance = age_group_influence - 0.13;
        }else if(agents[i].age_group == 1){//age group 10-16
            age_group_chance = age_group_influence - 0.1;
        }else if(agents[i].age_group == 2){//age group 17-22
            age_group_chance = age_group_influence + 0.1;
        }else if(agents[i].age_group == 3){//age group 22-28
            age_group_chance = age_group_influence ;
        }else if(agents[i].age_group == 4){//age group 29+
            age_group_chance = age_group_influence - 0.2;
```

```
        }


        // Determine the chance of influence based on thinking style
        float thinking_chance = (agents[i].thinking == 0) ?
thinking_influence : 0.0;


        // Determine the chance of influence based on economic
condition
        float economic_chance = 0.0;
        if (agents[i].economic_situation == 0) { // Consider lower
class for influence
            economic_chance = economic_influence+0.1;
        }else if(agents[i].economic_situation == 0){// Consider
lower- middle class for influence
            economic_chance = economic_influence;
        }else if(agents[i].economic_situation == 0){// Consider
middle class for influence
            economic_chance = economic_influence -0.5;
        }else if(agents[i].economic_situation == 0){// Consider
upper middle class for influence
            economic_chance = economic_influence -0.1;
        }else if(agents[i].economic_situation == 0){// Consider
upper class for influence
            economic_chance = 0;
        }


        // Calculate total chance of influence
        float total_chance = language_chance + age_group_chance +
thinking_chance + economic_chance;
        // Apply influence if there's a chance
        if (total_chance > 0.0) {
```

```
        // Check if language2 of agent i is same as language1 of
agent i+1
      if (agents[i].language2 == agents[i + 1].language1) {
        // Generate a random number to determine if influence occurs
        float rand_val = (float)rand() / RAND_MAX;
        if (rand_val < total_chance) {
            // Exchange the religious beliefs between agents i and
i+1
            int temp = agents[i].religious_beliefs;
            agents[i].religious_beliefs = agents[i +
1].religious_beliefs;
            agents[i + 1].religious_beliefs = temp;
        }
    }
}

    }
}


void print_agents_csv(Agent agents[], int timestep, const char*
filename) {
    FILE *fp = fopen(filename, "w");
    if (fp != NULL) {
        // Print headers
        fprintf(fp, "Agent,X,Y,Religious
Beliefs,Language1,Language2,Economic Situation,Thinking,Age
Group\n");

        // Print data
        for (int i = 0; i < POPULATION_SIZE; i++) {
```

```
            fprintf(fp, "%d,%d,%d,%d,%d,%d,%d,%d,%d\n",
                    i + 1,
                    agents[i].x,
                    agents[i].y,
                    agents[i].religious_beliefs,
                    agents[i].language1,
                    agents[i].language2,
                    agents[i].economic_situation,
                    agents[i].thinking,
                    agents[i].age_group);
        }

        fclose(fp);
        printf("Agents printed to %s\n", filename);
    } else {
        printf("Error opening file.\n");
    }
}

int main() {
    srand(time(NULL));

    Agent agents[POPULATION_SIZE];

    initialize_agents(agents);

    printf("Initial Data:\n");
    print_agents_csv(agents, 0, "initial_agents.csv");

    // Run simulation steps
```

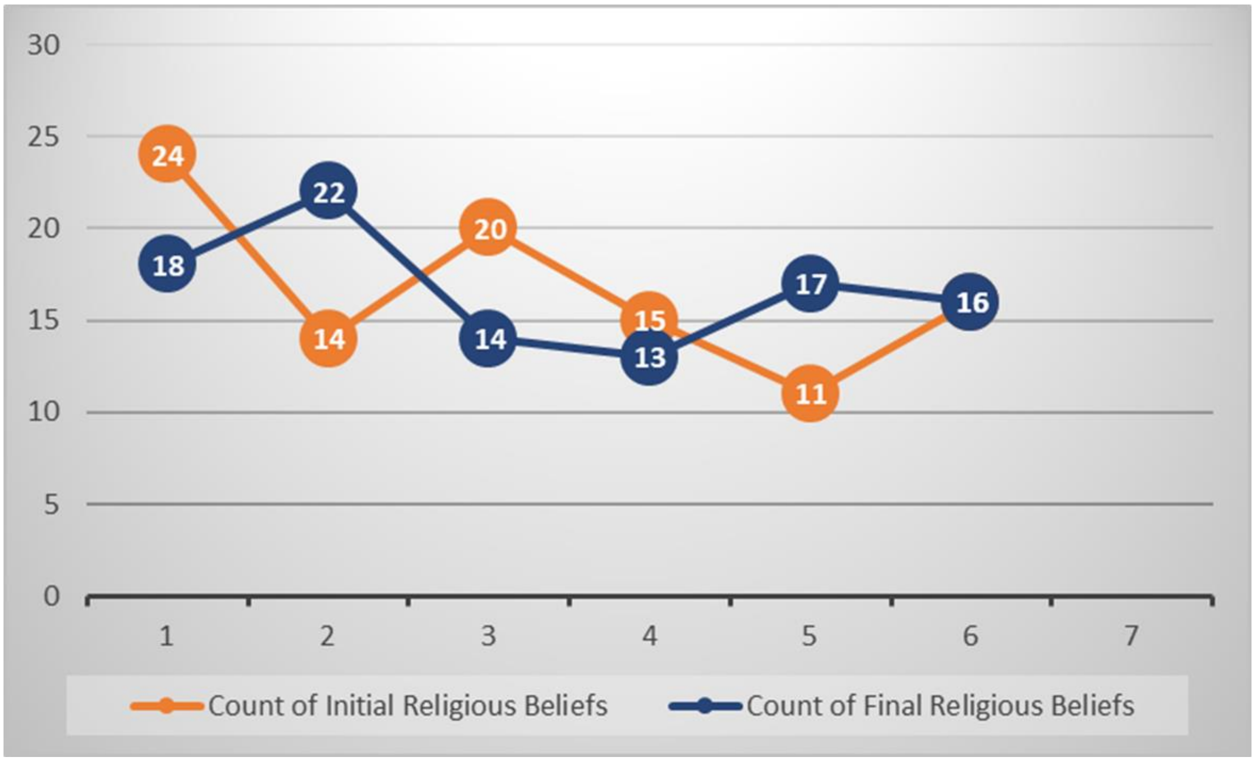
```
    for (int t = 0; t < 10; t++) {
        move_agents(agents);
        update_traits(agents);
    }

    printf("Final Data:\n");
    print_agents_csv(agents, 10, "final_agents.csv");

    return 0;
}
```

Observation

Comparison of Initial and Final count of releigion



X- axis represent

1 - Buddhism

2 - Christianity

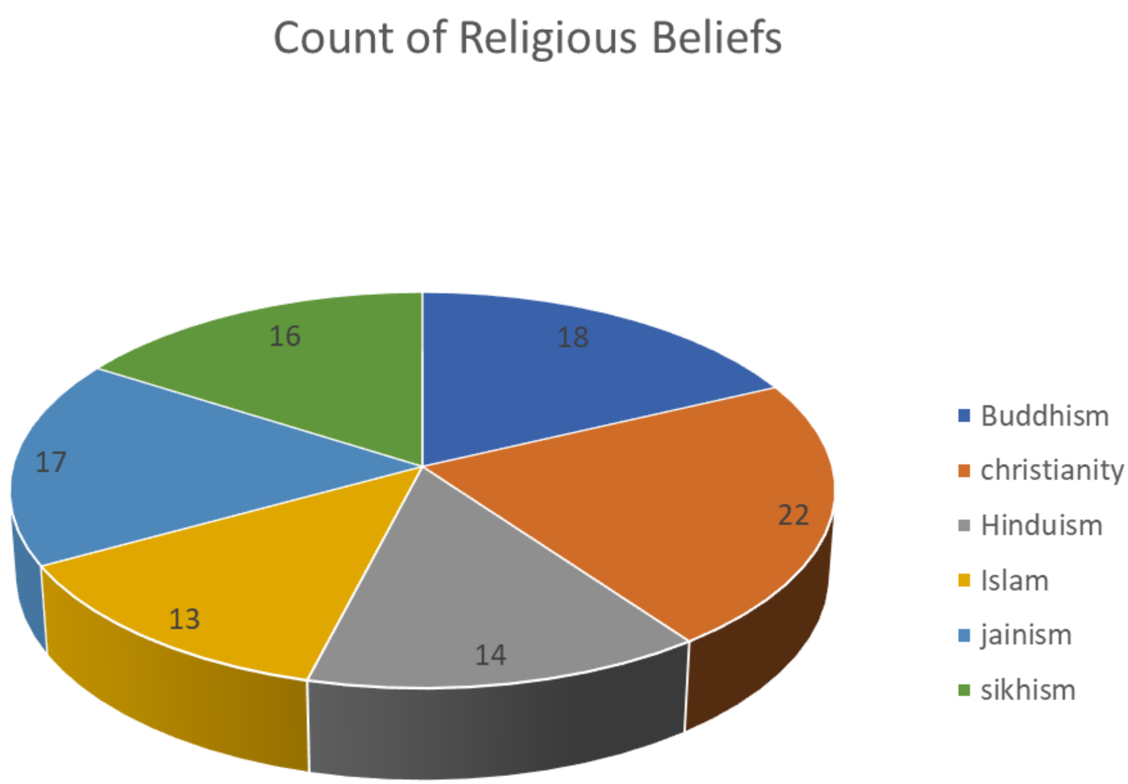
3 - Hinduism

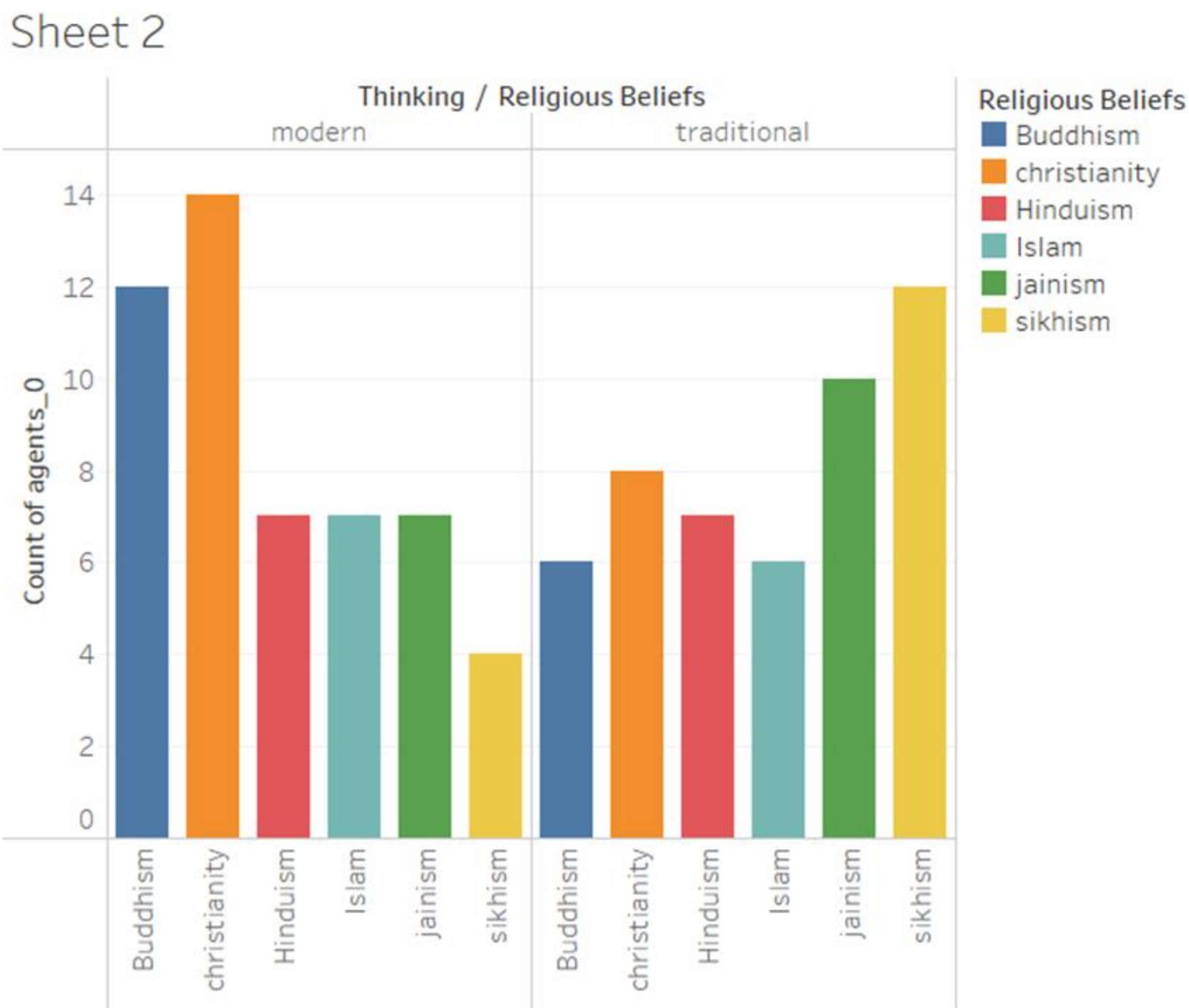
4 - islam

5 - jainism

6 - Sikhism

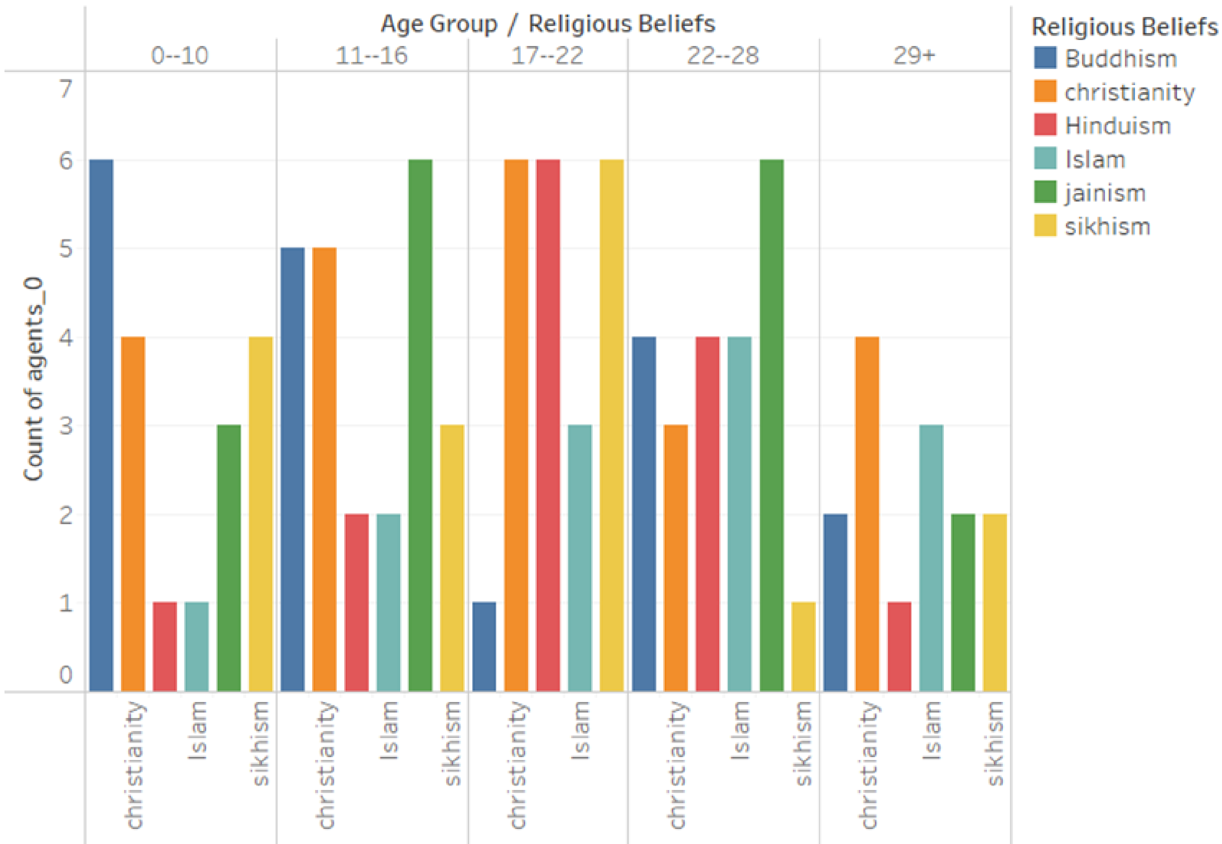
Initial distribution of Religion





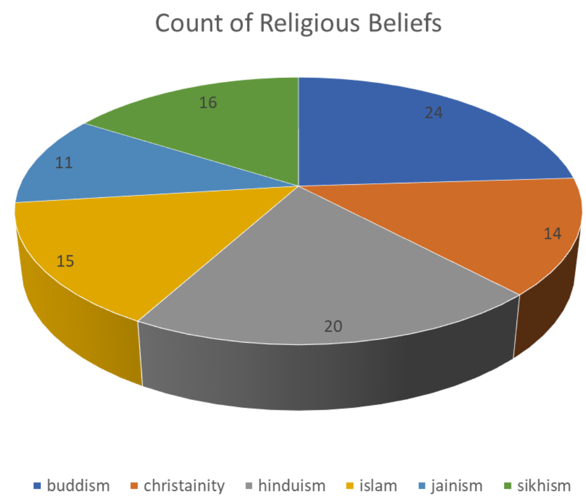
Count of agents_0 for each Religious Beliefs broken down by Thinking. Color shows details about Religious Beliefs. The view is filtered on count of agents_0, which ranges from 4 to 14.

Sheet 1

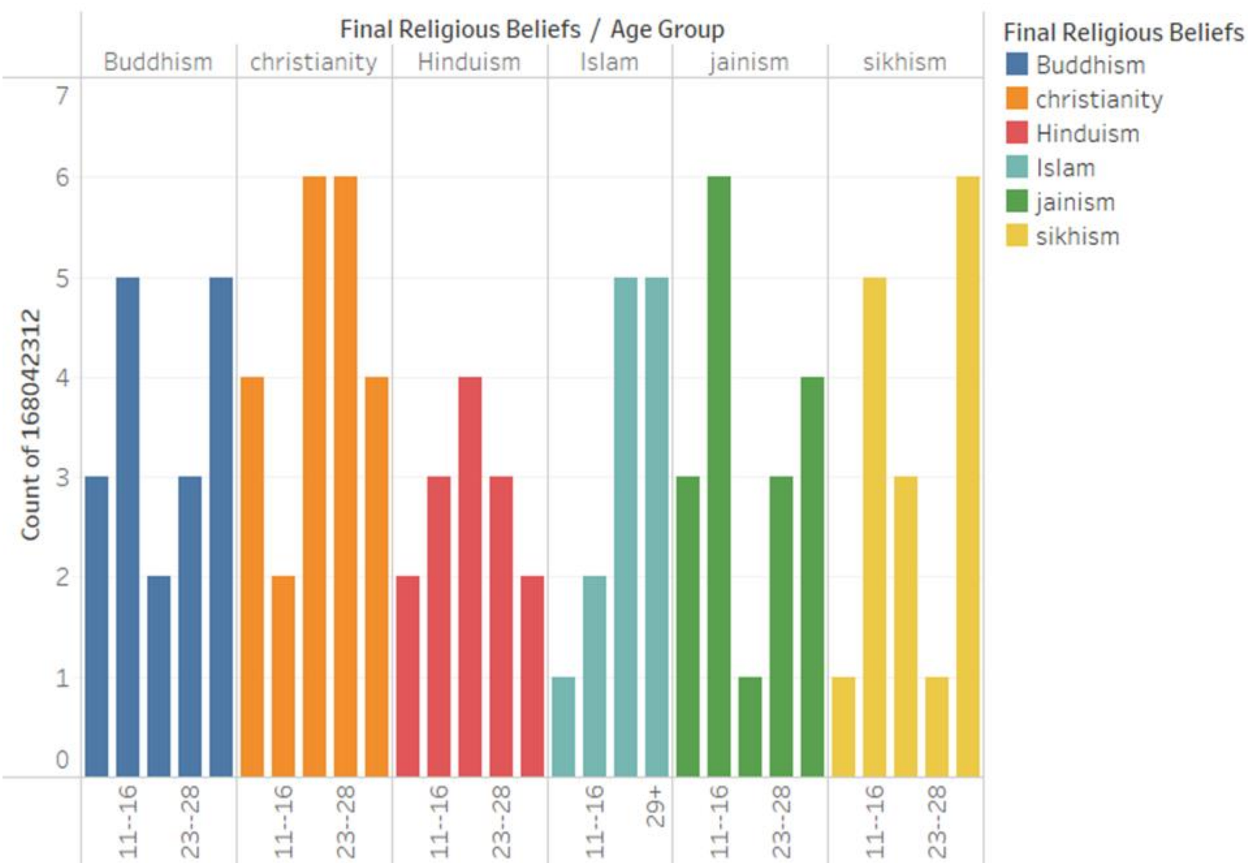


Count of agents_0 for each Religious Beliefs broken down by Age Group. Color shows details about Religious Beliefs.

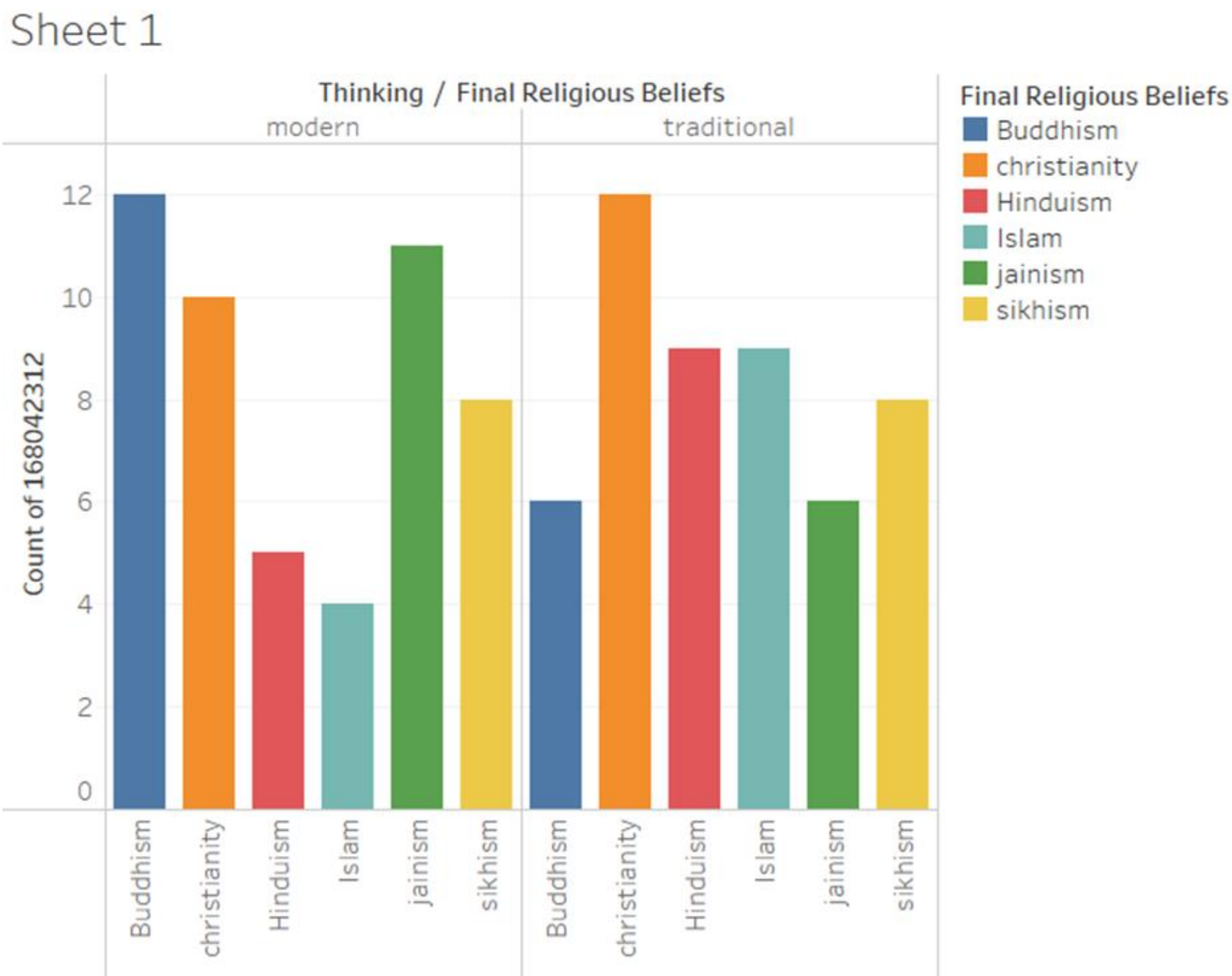
final distribution of Religion



Sheet 1



Count of 168042312 for each Age Group broken down by Final Religious Beliefs. Color shows details about Final Religious Beliefs.



Count of 168042312 for each Final Religious Beliefs broken down by Thinking. Color shows details about Final Religious Beliefs.

Result

•Enhanced understanding of Human behavior in response to Religion conversion under certain parameters

•Better understanding of human behaviour for further research from a single point of view(Religion) in research of cultural evolution

•We can use this model to speculate religion conversion and make due policies regarding this but before that we will need to perform a survey for more accurate results
•This model also help us to understand how age group , thinking ,economic condition of a person affect him or her or how much these properties influence .

Key references And Citation

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Overview

Agent-Based Modeling of Cultural Evolution: Creating agent-based models to simulate and analyze cultural evolution, studying the dynamics of cultural change.