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AGEING DYNAMICS IN ARTIFICIAL AGENT SOCIETIES: A REVIEW

Swapandeep Kaur[1], Harjot Kaur[2]

[1]Student(M.Tech(CSE)), [2]Assistant Professor

Department of Computer Science and Engineering,

GNDU Regional Campus, Gurdaspur, Punjab (India)

ABSTRACT

Recent trends in demographic changes are because of rapid population ageing. The increasing ratio of older population over total population is represented as population ageing. Demographic transitions are caused by population ageing. These transitions include fertility, mortality, migration and ageing transition. The main cause of increase in population ageing is ageing dynamics. These dynamics differ by age and sex because population growth takes place age by age and differently from males to females. In important ways, the working of society is influenced by age and sex. On the basis of gender and age of people, groups are established by society to assigns roles and manage people. This phenomenon of ageing dynamics is simulated by some societies that are operating as artificial agent societies. An artificial agent society is a synthetic representation of a society, which contains artificial humans called agents.

This research work will primarily investigate various types of ageing dynamics in an artificial agent society, i.e. what are various categories of agents in different age phases in an artificial agent society and why they are in these age phases. Also, how ageing dynamics will affect migration, fertility and mortality dynamics in an artificial agent society.

Keywords: Ageing Dynamics, Demographic Transitions, Influenced Factors, Population Ageing.

I. INTRODUCTION

The ageing dynamics are unavoidable and have great impact in growth and success of the organization and living standards of societies. Ageing dynamics differ by age and sex because population growth takes place age by age and somewhat differently from males than females. It matters not just how fast the population is growing, but which age and sex groups are growing and which one are growing faster or slower than others. Generally, dynamics are the changes in biological and social factors of population. Therefore, Ageing dynamics are the changes in physical, biological and also in position of people from youngest to older ages. These changes occur in the distribution of a population by age and sex when a society goes through demographic transition. Age and sex structure represents powerful forces for social, economic and political changes and a source of demographic change as well. Ageing dynamics affects both young and old population. A young population is one with high proportion of young people, whereas an old population is one with high proportion of elderly people.

In general, it is the interaction of fertility, mortality and migration that produces the age and sex structure, which can be viewed as a key to the life of social groups or agents. Biological changes of agents are described by *Ageing*. "The shift of age structure in ageing of population of societies described by *Population Ageing".* Population processes are not only produced by the age and sex structure but also are affected by it.

1.1 What is an Ageing?

Definition: *"In simple words, Ageing can refer to the passage of time or process of growing old." (or) "Ageing is the changing number of people at each age that occurs with the decline of mortality and then the decline in fertility presents the most obvious demographic pressure for social change"* [1].

When both mortality and fertility are high, the age structure is quite young, but the decline in mortality makes it even younger by disproportionately increasing the number of young people. Then, as fertility declines, youngest ages are obviously again affected first, since births occur only at zero, so fertility decline shows up first as simply fewer young, children than before [1].

Ageing is the process of becoming older, and it is process that is genetically determined and environmentally modulated. In humans, ageing represents the accumulation of changes in human beings over time, encompassing physical, psychological and social changes [2]. Demographic ageing has become a topic in social, economic, healthcare and even cultural debate because of the scale of its effects and its persistence [2].

1.2 What is Population Ageing?

Definition: *"Population ageing means "the process of change in the population's age group structure in the sense of an increase in the elderly group's ratio to detriment of the young group, as a visible and long-term trend" [20].*

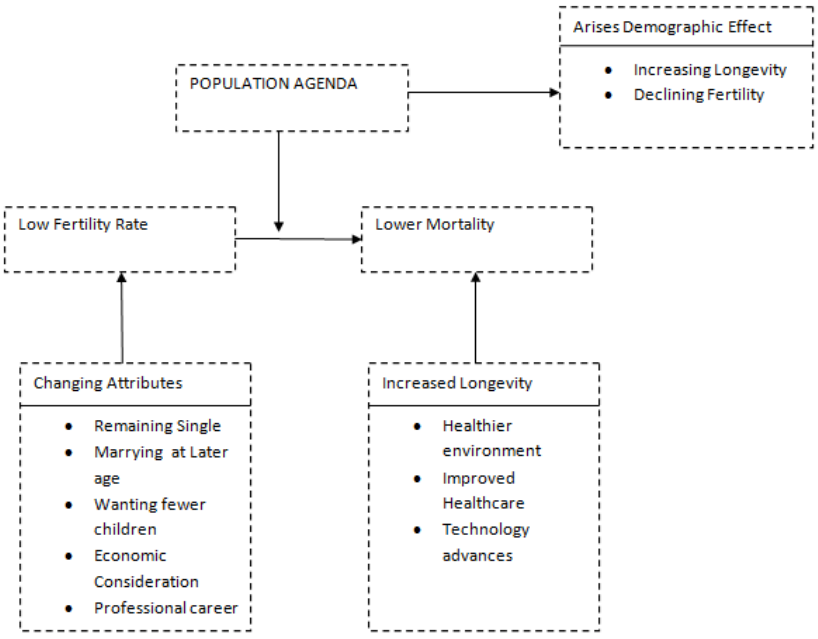

Fig1. Population ageing and its various demographic effects

Population ageing is a shift in the distribution of a region's population towards older ages. This is usually reflected in an increase in the population's mean and median ages, a decline in the proportion of the population composed of children, and a rise in the population that is elderly [2]. For analysis of population ageing structure and ageing dynamics, [10] artificial agent societies are used. They are used to describe the human societies for computer simulation in social analysis [9].

Population ageing arises from two demographic effects: increasing longevity and declining fertility [8]. The increase in longevity increases the average age of the population by increasing the numbers of surviving older people. A decline in fertility reduces the number of babies and as the effect continues, the numbers of younger people in general also reduce. Low fertility rates and lower mortality are the main causes of population ageing as described in figure1.

1.3 Demographic Transitions

Demographic transition theory emphasizes the significance of economic and social development, which leads first to a decline in mortality, and then after some time lags, decline in fertility. It is derived from the modernization theory [3][4].

The demographic transitions include the mortality, fertility, ageing, migration, urban and family/ household transition. They not only provide the causes but also the consequences of population change [5]. Usually, the first transition that occurs is the *mortality transition* - the shift from deaths at younger ages due to communicable disease to deaths at older ages due to degenerative diseases. This transition is followed by the *fertility transition*- the shift from high to low fertility. The predictable changes in the age structure (the age transition) are caused by the mortality and fertility transitions. And, it produces social and economic reactions as societies adjust to constantly changing age structure [2].

The rapid growth of population ageing is caused by the declining mortality more rapidly than fertility. This increases the population of rural areas, producing the *migration transition*. Especially, migration transition, occur in urban areas, creating the urban transitions. *Age Transition* is changes that accompany longer life, lower fertility, and older age and sex structure, and economic growth, all of which are parts of the demographic transition [1] [11]. The inter-relationship amongst these transitions is shown in figure2.

Fertility (Birth), Mortality (Death), Migration and Ageing transition drive the population changes and influence *age and sex structure, economic growth, population distribution and population density.* These are also called determinants of demographic change [2].

- *Mortality Transition:* Mortality is the rate of death and is one of the most important indicators of demographic changes. It reflects the social and economic development, which requires attention to the care of older people (60+ years) [6] [7].

When morality gets decline, the transition process begins. When the agents of society adapt changes in their behavior as a result of it, their health get improved and get ability to resist diseases. Mortality rates are also called Death rates. This rate is different for every age group. Young people have more life expectancy than the old people. Thus, the initial impact of the mortality transition is to increase the number of young people who are alive [6].

➢ *Fertility Transition:* The fertility transition is expressed as total fertility rate. In any population, it is the number of births that can be expected to occur. The fertility transition does not depend on mortality i.e. in other words we can say that decline in mortality does not always lead to the fertility transition. In most areas, it is the decline in mortality, which leads to greater survival of children. As a result of this process people start thinking of limiting their number of children. The main thing is pointed out that by this transition increases the number of older people due to decline in mortality [9].

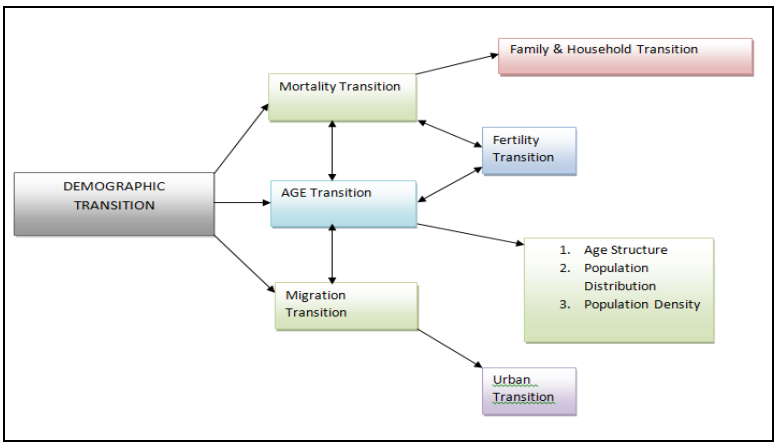

Fig2. Demographic Transition Dynamics

➢ *Migration Transition:* Migration is the third and the vital transition that causes the demographic changes in a society. It includes shifting of geographical population within nation and across borders. By declining mortality, growing number of young agents will lead them to become migrants elsewhere in search of jobs and economic opportunity[19].

➢ *Age Transition:* Ageing is the "master" transition that represents the demographic pressure for social change, which occurs due to change in number of people at each age as a result of decline in mortality and then decline in fertility. Age structur is quite young when both mortality and fertility rates are high, but the decline in mortality makes it younger by increasing the number of young people [2]. When fertility declines, youngest ages are again affected first due to zero birth rate and young ages before fertility decline get pushed to older ages [12].

We can say that the age transition is related to an ultimate age of advancement with respect to living standards. This ageing transition includes the young agents of working ages, those having few children and also the increase in size of older population. The increased size of older population, create the dependency problem of older population upon younger agents [11]. This particular age can be transitory, if a society has not planned for the next phase of age transition. At this time, the older population begins to increase more rapidly than the younger population. In this paper, the main focus is on how the societies will respond to the challenge of an increased older population [11].

1.4 Ageing Dynamics in Artificial Agent Societies

The Population ageing can be best simulated by using artificial agent societies. (Or) We can say that the impact of ageing on organizations or on societies is one of the critical issues which can be analysed by the use of artificial agent societies.

Artificial agent societies provide specific agent based computational model for computer simulation in social analysis. An artificial agent society (AAS) is a synthetic representation of a society. It simulates social phenomena. Artificial societies are used to understand how societies work by synthetically creating population in them [10]. The impact of ageing on organization or on societies is one of the critical issues that can be simply described by dynamics in age and sex structure of employees/agents. Experience of employees in an organization increases with increase in their age. The experience of employee can be shared by multiple employees who are new within the agent society. The workload on employee should decrease as age increases. The proposed work studies the impact of aging population. This impact can be studied by the application of artificial agent societies. This work can be studied by researchers to enhance the utilization of artificial agent societies in future endeavors [11].

Nowadays, with the increase in the number of older people, there is a need to expect their numbers in order to develop strategies and future plans for them. In age structure of population, there is increase in the number of elderly people and decreased trend of their morality rates, which is considered as a natural result of reducing the diseases spread among the elderly and the efforts of health care for them. The older -population having heavy economic burden on society need a special care [11].

The presented work deals with study of effect that aging dynamics have on organization or on societies. Henceforth, best possible ways can be suggested through the proposed work [2]. The age of an agent within the organization or in society results in experience this can be broadcasted to new agent under distinct situations that will analyse and measure the age of agent.

1.5 Paper Organization

The section I gives introduction about the ageing dynamics including ageing's definition and types. The background and related work is covered in section II. The section III presents various research gaps observed in background work. Then, the section IV discusses various ageing dynamics present in human and artificial societies. Various conclusions extracted from this work are presented in section V.

II. BACKGROUND AND RELATED WORK

In this section, we have tried to summarize various works, which have been performed and are related to ageing dynamics in artificial agent societies, i.e. what are various categories of agents in different age phases in an artificial agent society and why they are in these age phases. Also, we have illustrated how ageing dynamics will affect migration, fertility and mortality dynamics in an artificial agent society.

The existing literature is analysed to derive conclusions based on population ageing. This section provides detail description of existing work.

Mayer et. al. [12] have contended that the estimation of age, age organizing, and the life course have turned out to be more risky as the investigation of human lives has advanced towards point by point examinations and

clarifications. Their scientific investigations of the life course should take into account the heterogeneity, irregularity, and possibility that exist in present-day social trends. Prior life cycles or life courses depended on all encompassing originations of human lives and their age structure. This is how, as the scientific analysis of human lives and their age structure turned out to be more explained for academic disciplines as well as within them.

Watterson et. al. [13] have proposed a report with respect to trek and falls of travellers at railroad stations. This report likewise decides the future trails in such manner. The fate of population ageing with regards to railroad station up to 2050 is anticipated. Elements including falling and ageing are described through components investigation.

Peng et. al. [14] have proposed population ageing sway on wearable medicinal services condition. The contextual analysis of Chinese populace is directed. The necessities of individuals group adjust as the age improves. This paper limitlessly concentrates ageing impact on prerequisites and the ageing impact on everyday human health care systems. Along these lines, this paper plans to address this learning crevice by giving an account of an exploratory review that researched more established Chinese individuals' client prerequisites towards wearable human health care gadgets. This work however can't be actualized in summed up condition. The simulation is not conducted by artificial agent society which deals directly with real life situations.

Collard et. al. [15] has suggested the running efforts in the latest research on the demographics of ageing. Two distinct assortments of work have considered in this paper, are the markers of ageing. These bodies are not in light of the consistency of the age at which one turns into a more established individual. Right off the bat, they characterize an individual's age. Individual age is not as indicated by the quantity of years lived since birth, however as indicated by the staying number of years that he or she is relied upon to live. In this manner, their procedures consider a person as a more established individual when his or her life expectancy is less than ten years. This sort of portrayal might be utilized to characterize the extent of more seasoned people in a population. The significant headway in this paper is the refinement amongst individual and population ageing. This thought has been sought after by Sanderson [22], who set up the mean age of an age pyramid that is recalculated on the life expectancy at each age.

Arshad and Bhut et. al. [16] have described that the ageing of the population falsification a huge test and requirements on the developing and developed nations. This paper depicts that the ageing is the wedge of life portrayed by growing old and a standout amongst the most earth shattering patterns which has imperative implications for all parts of society. Population ageing likewise exhibits social, monetary and cultural difficulties to people, families, societies and the worldwide group. This paper exhibited an attempt to highlight the demographic phenomenon from worldwide viewpoint including both developed and developing societies.

Weil et. al. [17] have proposed a work that tells about population ageing is a worldwide pattern, yet its effects are occurring more quickly in industrialized nations. They learned about Italy's projected demographics, which is essential to perceive the trouble of gauging future age structures and failure to describe demographic phenomenon, for example, the "time of increased birth rates". Additionally tells that the aggregate fertility is hard to anticipate later on, and the effects of fertility motivator policies are required. Migration alone is not an

answer for the issue of population ageing. It might give here and now intends to expand dependency ratios and can carry on as transitory help to work market structures and social security frameworks.

Willis et. al. [20] have proposed a report on distinguishing proof and description of ageing and the development of the old populace. This report likewise describes how to execute new and improved information accumulation techniques. Consequence of this work accompanied increment in life expectancy of elderly populace.

Stoica et. al. [21] have given a report on the procedure of population ageing. This ageing procedure impacts all segments of society and its practical association groups. This report depicts the elements of Sartell Hydrographic Basin, to finish up the procedure of demographic ageing and furthermore portrays the impacts of population ageing on rural areas.

III. RESEARCH GAPS

The above mentioned literature elaborates the work which is done in direction of population ageing. The population ageing is the major cause of dynamics in demographic transitions. These dynamics of demographic transitions are affected by fertility, mortality and ageing. The dynamics in ageing have great impact in growth of organization or society. Dynamics are simply the changes. These changes occur in the distribution of a population by age and sex structure of country as a country goes through various demographic transitions. Various research gaps can be identified from the surveyed work:

- The existing work on ageing has not been simulated by artificial agent societies.
- Ageing society's interaction with other societies is not considered.
- Identification and description of ageing population is not covered in previous work.
- Demographic ratio is not utilized in most of the surveyed work hence ratio of young to old persons cannot be estimated accurately.
- It is difficult to measure the age of agents in artificial agent societies.
- No description about age dependencies, how groups are dependent to other age groups.
- The Causes of growth of older population have not been discussed under artificial agent societies yet.
- No research work is performed that which age and sex groups are growing faster or slower than other groups.

All of above conditions have not been discussed in the above mentioned works. Henceforth, there is a big need to resolve this issue. These enhancements can be pursued as one of the future research directions.

IV. AGEING DYNAMICS

Dynamics are changes that occur in behavioural and in societal resources or attributes of agents. The ageing dynamics used to describe the behavioural changes as a result of ageing transition and it effect on society. The agent societies can be considered to describe this mechanism and approach [18]. The societies are formed by considering distinct behavior that agents possess. The agents having same attributes are grouped together with in the same group. We have proposed the following model describes the dynamics of population ageing in artificial agent societies. *The Population Ageing Model* shown in following figure3.

The effects of *Population ageing* on various societies are considered. These effects of population ageing are described by the model of population ageing. The impact of population ageing is the increase in number of older

people, caused by a decline in mortality and also caused by decline in fertility as described in diagram. These changes are partly the result of *individual ageing*- people change biologically with age and societies react differently to older than to younger people, producing the social changes that accompany population ageing. These individual changes describe the interface ageing affect including effect on new, young and old persons. These individual changes occur in the context of each birth cohort, because improvements in health are changing by technological and environmental changes in life over which we have very little personal control.

Population ageing and *Individual ageing* combine to produce ageing transition in society. It will change the sex and age structure of the older population. An age and sex structure represents the number of a given age and sex in society and is built from the input of births at zero and from death caused by diseases or other factors. There exist parameters which are affected by the ageing. Primarily, aging parameters considered Gender (male/female), Types of Age, Age phases, Dependencies and Influenced factors. The age effect on males is different than on females. The parameters for studying ageing affect are described as under:

1) *Gender:* It describes type of agent in terms of male or female. Generally, more male babies than females are born, but more males than females die at older ages. In most societies, females outnumber males at older ages.
2) *Age:* There are some different perspective on how to classify someone's Age:-

a) *Chronological age:* Chronological age tells the number of years a person has lived.
b) *Biological age:* A description of an individual's development based on bio markers comes under biological age. Biological ageing refers to a decline in physical abilities in older people accompanied by increased risk of illness.
c) *Psychological age:* Age of an individual determined by degree of emotional, mental, and physiological maturation comes under psychology. Now we are trying to say how old a person is without bio marker.
d) *Functional age:* It is a combination of physical, biological and chronological age. Functional age would give you the clearest understanding of a person.

3) *Dependency:* Age wise dependency exists. As the age increases dependency on others increases. Various dependencies of older population exist in the proposed model which leads to burden on younger population. Some of these dependencies are described as following:

a) *Physical Dependencies:* Due to age factor older people become less physically capable to survive. They become less conscious and less physically active. Their stamina gets reduced up to a great extent. This is how they have to depend upon youth. This dependency can be reduced by keeping personal healthcare agents or assistants.
b) *Economic Dependencies:* Economic burden reflect on the active proportion of the population of working age. Economic dependency exists when non-active population is dependent on active population. In other words, older population dependent on younger population financially.
c) *Control of Societal Resources:* Control of societal resources comes under older population because of their properties and welfare which depends upon their life expectancy rate that is higher than younger population. Other societal issues like controls, responsibilities are also under the older population.

The age can adversely affect the performance of an organization. The factors which are influenced through ageing are described as under:

- *Fertility:* Lesser the fertility rate, lesser the number of young ones and higher the older population. This mechanism cause burden on the society where lesser the number of working ages.
- *Mortality:* Mortality is inversely proportional to age. Mortality decreases with age. At older ages, mortality of males is more than the mortality of females.
- *Need:* Needs increases with age. Hence need is directly proportional to age.
- *Education:* Better education is a very important factor that raises the opportunity for children and encourages women to limit fertility. The literature survey over the last few hundred years has meant that each generation of older people tends to be better educated than previous generation. This will generate a better society for every age group.

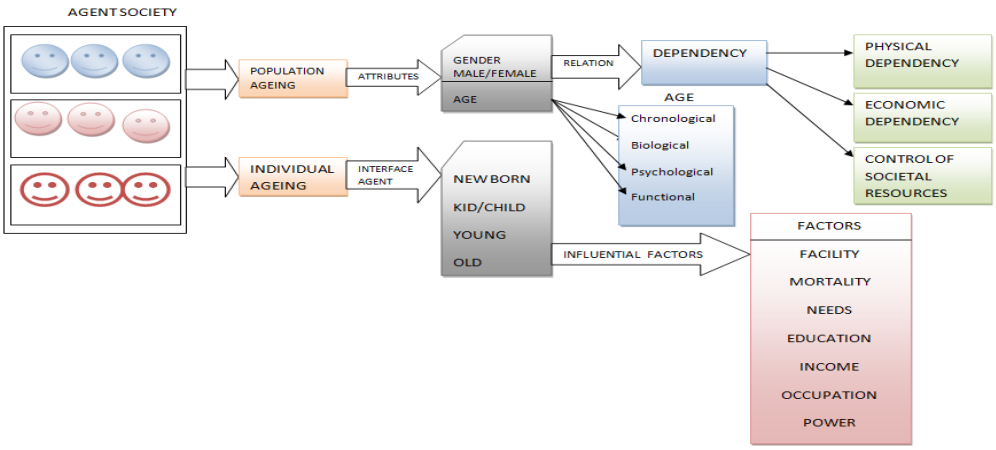

Figure3. Population Ageing Model

- *Occupation:* Occupation gets higher as the age of an agent increases. It is a clue to lifestyle and an indicator of social status, pointing to a person's social status and position in the social hierarchy. From a social point of view, occupation is so important that it is often the first question a stranger may ask about you. It provides information about what kind of behavior can be expected from you, as well as others will be expected to behave towards you.
- *Power:* Power decreases as age increases. Therefore, this affect is inversely proportional to age.

V. CONCLUSIONS

In this paper, we have presented, various types of ageing dynamics existing in artificial agent societies. As, mentioned in the related work section, many authors have presented their work on population ageing but none of them is providing deep insight into the dynamics of agent's population ageing. All the dynamic aspects which are discussed by us for population ageing in artificial agent societies are inspired by the dynamics aspects of human ageing, as both of them have quite similarities. We have elaborated on types of ageing and effects of population ageing on older population as well as younger population. Also, we have discussed various dependencies of older population which leads to burden on younger population. Also, we have formulated in

this paper, a model of *population ageing*. This model throws a light on the population ageing as well as individual ageing and their influenced factors. Attributes like gender, age groups and relation between these groups in the form of dependencies are also described in the model of dynamics of ageing population in artificial agent societies.

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