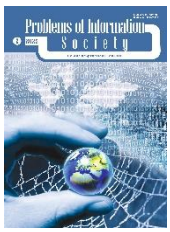

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Digital cemetery: challenges and prospects

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ABSTRACT

In a modern society where the electronic government is being formed, state institutions and various commercial structures are trying to study and assess the behavior, interests, role and reputation of citizens in society based on personal data arrays. However, when people die, the information collected about them loses its immediate significance for current operational purposes. As a rule, this information is deleted or archived in accordance with the established protocols for data storage and legislative requirements for the protection of personal data of deceased persons. In the context of preserving national and cultural heritage, restoring historical memory and in-depth study of society, the process of collecting, structuring, and processing information about deceased persons is of particular importance. The concept of creating a digital twin of a deceased person by linking and processing different data represents an innovative approach to effectively immortalizing them. This article defines the role of information technologies in the preservation of cemeteries, explains the essence of the digital cemetery concept, and presents the general structure of the digital cemetery system. It determines the importance and potential prospects of the digital cemetery system for society, and develops proposals for its effective operation.

1. Introduction

Cemeteries are the places where deceased people are buried and memorialized, representing the characteristic features of society and the national customs and traditions of each nation (Nordh et al., 2018). Cemeteries are an important part of the ecosystem of cities, towns, and other settlements, and refer to public parks visited by people (Swensen at al., 2018). For centuries, people have placed cemeteries outside residential areas and in safe places as a sign of respect for the souls of the deceased. Today, many of these cemeteries are being destroyed through natural disasters, wars, and demographic processes.

Another reason for the destruction of cemeteries is neglect and vandalism. Recently, climate change, primarily extreme climatic conditions as a result of warming, have further accelerated the process of destruction of cemeteries. It is often impossible to protect cemeteries from natural disasters and military conflicts. Relocating them from one place to another is very expensive (Pulver, 2023). The issue of preserving and restoring old cemeteries remains a problem all over the world. Cemeteries and tombs are forgotten over time. In many cases, the lands on which cemeteries are located are given to private property. It is also impossible to understand who owns and is responsible for these cemeteries, and therefore the protection of the tombs there becomes even more difficult.

From ancient times to the present day, people living on Earth have become famous scientists, philosophers, artists, and doctors of their time (Johan, 2022).

As a result of excavations in abandoned ancient

cemeteries, scientists acquire new information about the history, culture, and lifestyle of the people who once lived in these places. Due to excavations in ancient cemeteries, it is possible to obtain information about the diseases that people suffered from, epidemics, and wars. The lifestyle, culture and cause of extinction of the tribes that lived in those lands for ages can often be determined only by studying the cemeteries.

In terms of modern globalization, people often separate from their families and places of birth and live in different cities and countries. When people living far from their loved ones and family members die, it is often not possible for their relatives and friends to visit their graves. And there becomes a need for digital cemeteries to commemorate these deceased.

Digital cemeteries offer a potential solution for keeping the deceased alive virtually. This article examines scientific research related to digital cemeteries, present digital cemeteries projects, and identifies potential advantages and problems of this concept. It analyzes the role of information technologies in the protection of cemeteries, and develops a general structure of the digital cemeteries system. At the end of the study, it touches upon the ethical considerations regarding the confidentiality, presentation and accessibility of data in digital cemeteries.

2. Related work

A digital cemetery, although available online, functions like a real-life cemetery. However, there are some exceptions – a visitor can visit a digital cemetery any time and from anywhere, regardless of their location. A digital cemetery can be generated any time, is accessible to Internet users, and various information about the deceased is stored in a database (Digital Graveyards Project).

2.1. Scientific research on digital cemeteries

In recent years, extensive research has been conducted on digital cemeteries. Most of these studies examine the problems associated with the preservation of digital heritage and the online presence of the deceased, as well as access to the personal data of the deceased, and proposals for solving the problem are developed (Chu, 2015, Gamba, 2020).

(Schmidt et al., 2022) uses the geospatial technologies to analyze the Woodland Hills Memorial Park cemetery. Here, using manuscripts and a global positioning system (GPS), spatial data of the graves are collected with high accuracy, and mapping and demographic data analysis, and ethnic groups are performed based on the obtained geodata. GPS is a satellite navigation system designed to determine the geographical position of an object. The proposed method can facilitate the collection, mapping, and analysis of grave data locally for planning and historical and cultural research.

Another study examines the diversity of urban cemeteries. The multifunctionality of cemeteries and their importance as a sustainable urban landscape are presented and their current status is assessed (Säumel et al., 2023).

In (Agostini et al., 2024), the authors note that traditional urban cemeteries face spatial constraints, pollution and a number of environmental problems. The article proposes a sustainable, urban-integrated model with green spaces, efficient use of resources and smart technologies, and shows this model to have the potential to create more humane and environmentally friendly urban cemeteries. (Nakagawa et. al., 2024) examines Japan's "digital identity" commercial project. The study found cases of people's images being used in advertising even after their death. A social survey showed that approximately 20% of people are willing to allow their personal data to be used for commercial purposes during their lifetime, provided that they receive compensation. The study develops proposals for using the personal data of the deceased without damaging their reputation.

An example of demographic studies based on cemetery data is the study of "life tables" based on statistical data showing mortality and survival rates, and the methods for constructing survival curves based on these tables (Lanza, 2012). The authors analyze different population groups (e.g., geography, time, gender, socioeconomic status, and ethnicity) using data obtained from gravestones, online cemetery archives, and censuses.

(Şchiopu, 2022) describes the essence of the "smart cemetery" concept, offering new methods for processing personal data necessary for the efficient operation of these cemeteries. Betsward et al. (Betsworth et al., 2024) propose mobile applications that provide information not only about the cemetery, but also about the geographical area, flora, and fauna in which it is located, based on QR codes (Quick Response codes), which are used to share and retrieve various information quickly and easily. The main goal of their work is to encourage people to visit these places. Thus, frequent visits to cemeteries by visitors are important both for the deceased not to

be forgotten and for the preservation of the cemetery.

The study presented in (Jonna et al., 2019) is dedicated to the digitization of the Salla cemetery, located on the border of Finland and Russia. Along with obtaining extensive information about the graves, visitors of the digital cemetery can also place "candles" on virtual graves. Although the simulation is considered immersive, visitors require more authenticity and new details such as the ability to light a virtual candle and lay a wreath.

2.2. Present digital cemetery projects

Although digital cemeteries are a new perspective, dozens of websites have already been generated so far. For example, "Beautiful Tribute", "CanadaGenWeb's Cemetery Project", "Gone But Loved", "InMemoriam", "Bridges to the Past", "CandleMemorials" etc. are becoming popular (BillionGraves, 2021).

One of the most important virtual projects that can be used to preserve the material and spiritual heritage of peoples and create toponyms is the global "BillionGraves" platform. This project, which is one of the portals for digital cemeteries, is an open online database that collects data on cemeteries and graves around the world. Tombstones around the world are subject to erosion over time and the inscriptions on them are erased. One of the goals of BillionGraves is to digitally preserve all tombstones in the world. If a real tombstone is damaged, worn out, or destroyed, information about it will still be available on the billiongraves.com website. This project greatly simplifies the work of genealogists and family history researchers.

Graves are photographed all over the world, their exact location is determined by GPS, and they are uploaded to the billiongraves.com website along with the available information about the person who the grave belongs to.

In order to simplify the work process, a mobile application of the BillionGraves platform has also been developed. At the same time, the BillionGraves system has been integrated with other local and global electronic resources where information about families and genealogies is collected. Any Internet user can access the information in this system.

BillionGraves is a unique opportunity to get information about people who died in their homeland and abroad. Moreover, this platform is a very effective tool for documenting facts about historical lands occupied and lost by other neighboring lands, countries and empires that once existed, determining the population of territories, tracking migrations, and conducting historical research in various fields.

Unfortunately, the BillionGraves platform is not well known in Azerbaijan and its capabilities are not widely used. Thus, when searching the BillionGraves platform, it turns out that information about 200 graves in Azerbaijan is posted here.

The practice of creating a digital guide to cemeteries based on smartphones is becoming widespread. In England, the guide program created within the framework of the Future Cemeteries project not only provides detailed information about the deceased by touching the tombstone, but also collects information about visitors through sensors installed on the graves (Troyer et al., 2012).

The meSch project, which cooperates with the Sheffield General Cemetery Trust in the UK and aims to preserve the cultural heritage, is developing various concepts based on information about graves and the deceased. For example, a mobile user interface equipped with an audio guide, etc. (Ciolfi, 2013).

The installation of mobile navigator software in cemeteries and the use of QR-code visual markers are already becoming widespread (Stine, 2015). These technologies ensure quick detection of the searched grave, as well as provide general information about the deceased [Jonna, 2018]. Equipping cemeteries with navigation via mobile navigator program also provides quick access to information about the deceased and online visits to the cemetery.

Nowadays, digital cemeteries are of great importance for the preservation and study of our cultural and historical heritage. The lack of widespread use of these digital resources in Azerbaijan leads to certain losses. These losses include the loss of information as a result of physical wear and tear and destruction of tombstones, the difficulty of archaeological research, and the restriction of data access central for historical research. Given the potential of artificial intelligence technologies, it is possible to predict the widespread application of the digital cemetery concept in our country in the near future.

3. Materials and methods

3.1. Challenges related to cemeteries

Each cemetery preserves information about a certain period in world history. The study of necropolises can be one of the most important

tasks in the process of forming national identity and preserving historical heritage. There are cemeteries everywhere where people reside. Cemeteries refer to the tangible and intangible heritage of the people and their protection is essential. In order to effectively solve the issue of physical and virtual protection of cemeteries, the state-of-the-art and challenges related to cemeteries should first be explored. Some of the problems are listed below:

Information limitations

- When a person is born, the place of birth - country, city, village - is written on the birth certificate. When a person dies, information about the place of burial and the cause of death is not provided. In most cases, those who visit the cemetery are unaware of what the deceased did, how he/she lived, his/her interests and desires.
- Preservation of information about deceased people is one of the important factors for the protection of the national and spiritual values of the people. Changing the names of places due to certain political processes (occupation, forced migration, etc.) creates problems in the protection of the national cultural heritage of the peoples who lived in those places.
- Many cemeteries, far from densely populated areas, are neglected. There are no irrigation systems or lighting. As a result of the neglect of the graves, it becomes difficult to obtain any information about them.
- Although many cemeteries are located in areas under churches, mosques, and other religious institutions protects them from vandals, over time, some of the information about those buried there (those considered inappropriate from a religious perspective) is forgotten or changed.
- Due to the lack of information about the cemetery and the deceased, it is impossible to conduct an analysis of these cemeteries. In particular, there is no enough information for mapping old cemeteries and analyzing personal information of the deceased.

– ***Threat of destruction of cemeteries***

- Cemeteries are likely to be destroyed and forgotten for various reasons. These reasons may include wars, natural disasters (earthquakes, floods, etc.), population displacement, vandalism, etc.
- Despite the fact that cemeteries are laid outside residential areas, as cities and towns grew, most of these cemeteries have now become invisible among the buildings. There is no free space in such cemeteries to bury the deceased. Accordingly, the graves are reused, which means the destruction of old ones.
- Vandals often destroy old graves in search of loot.
- There are still cases of purchase, unauthorized changes and deliberate destruction of graves by the cemetery managers.
- Due to their remoteness from residential areas and transportation routes, most cemeteries become a haven for wild animals becoming a terrifying place for people. Especially at night, people do not go to cemeteries after dark due to the lack of lighting in the cemeteries.

Lack of coordination system in cemeteries

- The lack of a coordination system in cemeteries makes it difficult to find the grave of any person. Some grave owners use various memorialization methods: they create statues, busts on the graves, magnificent headstones made of marble or granite, etc. Such activities negatively affect the overall appearance of cemeteries, and also represent social inequality among the families of the deceased.
- Most cemeteries are difficult to identify on a digital map (Google Map, etc.) and it is impossible to find any graves there or get information about the graves.
- Cemetery maps showing boundaries, roads, plots and graves in cemeteries are traditionally drawn manually. Relevant information about burials is often stored in special registration books or spreadsheets. Manual mapping of cemeteries or the use of simple spreadsheets complicates the coordination and management of grave data. Moreover, paper maps and files are difficult to store. They are more likely to be destroyed or stolen. Paper materials are also vulnerable to disasters such as fire and flooding.
- Many developed countries try to solve the problem of cemetery mapping through Geographic Information Systems (GIS). However, the security, collection and storage of data in GIS require additional technical resources and specialists, which entail additional costs.
- Some people use physical markers (marks on stones and trees in the cemetery). Visitors plant various trees and exotic plants around the grave, concrete or fence the area around the grave. This activity is both harmful to nature and hinders the free movement of visitors in the cemetery.

Ecological problems

- Representatives of most Christian religions encourage the burial of the deceased in a coffin. Coffins are made of various materials, most of which are not biodegradable. Tombs made of pressed steel, reinforced concrete, and plastic materials cause changes in the composition of the soil and the course of groundwater. Accordingly, the area where the cemetery is located turns into a swamp or desert.
- There are concerns that coffins containing formaldehyde (a colorless gas) adhesives and various synthetic materials can cause environmental pollution when they decompose in the soil. Coffins are often made of exotic and even endangered trees. There are generally no restrictions on the type of coffin used.

Normative legal aspects

- Cemeteries are not identified from a legal point of view. Specifically, today the place where the cemetery is located, country, city, etc., are not identified with the names given by the people. From a geographical point of view, these territories are not recorded in land cadasters (lists of official bodies or departments) based on GIS and are not provided with appropriate certificates. Explicitly, even if the graves are registered in e-government registers, information about them is not available.
- Sometimes people working in cemeteries (guardians, gardeners, etc.) do not have legal documents.
- The rules in the legislation regarding funerals and cemeteries in different countries also vary. Gaps related to burials still remain in most laws. This is primarily related to the funerals and the protection of cemeteries.
- There are cases of funerals being used as a means of political and religious propaganda and psychological influence. There is no complete information about the religious education certificate, morality and lifestyle of the clergyman invited to the funeral.

Challenges in protection of national and cultural heritage

- The funeral ceremony is a type of national cultural heritage of the country and each nation. Burial may be in the form of inhumation (burying the body in the ground), cremation (burning the body), etc. How and for how many days the funeral ceremony is held, the form of the funeral primarily depends on religious aspects. The religion of the deceased is a key factor in the funeral ceremony. For example, for many Muslim nations, regardless of race and nationality, the funeral rules and ceremonies are almost the same and important to follow them. However, in some regions, attempts are being made to change the funeral customs that have existed for centuries.
- A funeral ceremony that is traditional for one people seems unacceptable for others. For example, in Tibet, it is common for the bodies of the deceased to be eaten by wild birds. In countries where Buddhism is widespread (India, Japan, etc.), cremation of the deceased is implemented. Recently, due to the increase in the cost of funerals and burial sites, the construction of crematoriums has become widespread in the USA and many European countries. After cremation, the ashes of the deceased are scattered in water or on the cemetery grounds. In most cases, the ashes are placed in a burial urn and either buried, or kept in a columbarium (special buildings in cemeteries) or at home. Such cases are unfamiliar to the culture of individual nations and can lead to their national cultural heritage to be forgotten.

The Republic of Azerbaijan has high control over the protection and improvement of cemeteries, but most of the above problems also exist in Azerbaijan.

3.2. Condition of cemeteries belonging to the Azerbaijani people

Cemeteries are all over the world where people live. Each cemetery preserves the past, culture and identity of a certain period in the history of any country. Cemeteries are a type of material and spiritual heritage of the people and are important for studying its cultural heritage.

The "Rules for the Establishment and Management of Cemeteries" were approved by the Decree of the President of the Republic of Azerbaijan No. 1789 dated January 18, 2018. The Rules "determine the requirements for the establishment, management, protection, relocation and closure of cemeteries, as well as for maintaining a unified state register of burials, exhumation and transportation of corpses" [e-qanun.az, 2018].

The "Rules for the Establishment and Management of Cemeteries" specifies that it is important to have a unified database of people buried in cemeteries in the Republic of Azerbaijan, that is, a unified state register of burials. The information stored in the unified state register of burials includes the surname, name and patronymic of the deceased, dates of birth and

burial; a medical certificate confirming the fact of death, place of death; the number of the cemetery in the register where the person is buried, the administrative territorial unit and address of the location; individual identification number; the number of the grave where the person is buried, its location in the cemetery, etc. However, this information is not sufficient to solve all the above-mentioned problems related to cemeteries.

In Azerbaijan, the "rahmat.az" project is developed regarding digital burials. The project is a virtual space created to preserve the memory of people who have passed away. This project provides users with various services such as creating a virtual memorial and posting any information about the deceased on the memorial page: photos and videos, memories, and stories about the deceased. Information about the deceased is available by scanning the QR code on the monument using a mobile phone (rahmat.az).

The destruction of the graves of Natavan, Vagif, Navvab, Bulbul, and many other well-known cultural figures in Karabakh during Armenian occupation, which made invaluable contributions to world culture and are internationally recognized, was primarily aimed at destroying the national cultural heritage of Azerbaijan.

Hundreds of historical and architectural monuments: mosques, tombs, mausoleums, and cemeteries in Western Azerbaijan, where more than a hundred thousand Azerbaijanis had lived for centuries, in the territory of present-day Armenia, were destroyed as a result of Armenian vandalism (qafqazinfo.az). Another example of the destruction of the national cultural and historical heritage of the Azerbaijani people is the modification of historical names of settlements belonging to the Azerbaijani people in the territory of Armenia.

The names of settlements often represent historical, cultural and symbolic meanings. After demographic changes and the establishment of new control over territories, new authorities often try to strengthen their ideology and history by changing the names of places. Starting from the beginning of the 20th century, the renaming and armenization of places inhabited by Azerbaijanis can be assessed as an affirmation of Armenian identity (Bayramov, 2011).

In the period from 1918 to 1987, 254 settlements belonging to Azerbaijanis were destroyed in the territory of Armenia; their population was either subjected to genocide or deported. These processes sustained with the armenization of toponymic names and the destruction of cemeteries in those lands.

The renaming of settlements, monuments and the destruction of cemeteries by Armenians is a painful issue with deep historical; complex political and demographic roots and serves to vanish information about the past historical and cultural heritage of these lands in relation to the Azerbaijani population. The Azerbaijani people and government estimate the policy of renaming settlements, monuments, mountains, rivers and lakes belonging to the Azerbaijani people on the territory of Armenia as part of a broader anti-Azerbaijani policy aimed at erasing the historical and cultural heritage of Azerbaijanis.

The Azerbaijani Ministry of Foreign Affairs regularly issues official statements condemning the renaming of Azerbaijani toponyms in Armenia. These statements emphasize that such behavior it an attempt to falsify history, destroy the cultural heritage of the Azerbaijani people and erase traces of centuries-old settlements in those territories. The Azerbaijani National Assembly (Milli Majlis) and various committees have also expressed their opposition to the renaming policy in Armenia (e-qanun.az, 2018).

Azerbaijan raises this issue in the UN, OSCE, European Council and other international organizations and forums. Azerbaijan actively conveys its position on this issue to the international community by presenting historical facts and documents. The country calls on the international community to condemn these actions of Armenia and take measures to protect cultural heritage (e-qanun.az, 2018).

The issue of altering names is often raised in the context of the right of Azerbaijani displaced persons to return to their homelands, which left Armenia as a result of the conflict. The Azerbaijani state believes that modifying toponyms, destroying historical monuments and cemeteries is an obstacle to the return of displaced persons and the restoration of historical justice.

3.3. The role of information technologies in the preservation of cemeteries

Due to the penetration of the Internet into people's daily lives, the difference between virtual and real lives is eliminating. People are increasingly integrating into the Internet, and information technologies, as the main provider of daily communication and social relations, affect the lifestyle of citizens. Widespread informatization, the progress of high-speed Internet, and the mass use of computers and mobile devices play an

important role in the protection, restoration and promotion of cultural heritage. Documents, images, audio and video files expressing people's lifestyles, traditions and history are collected and promoted on social media resources.

Recent programs converting mobile video calls, video recordings and images into animations create virtual copies of people, allowing to watch their movements and speech over and over again. Even when a person dies, information about him/her remains in a digital profile and continues to be used.

The concept of digital cemeteries is based on the collection and processing of information about deceased people, the digitization of cemeteries and graves taking advantage of ICT capabilities and, in particular, the Internet. In these projects, not only information about the deceased (personal data, cause of death, place of burial, visitors, etc.), but also all digital information about the relatives of the deceased can be collected and structured.

The creation of digital cemeteries is important for the preservation of national heritage and ensuring citizen satisfaction. The functionality of digital cemeteries can be grouped into the following areas:

- Linking the digital cemetery with information systems that collect citizens' personal data;
- Collecting and structuring data in the digital cemetery database;
- Creating a profile of the deceased in a digital cemetery and bringing information to this profile under a single personal identification number (PIN);
- Processing information about the deceased using datamining methods and creating a digital twin through visualization. Thus, a digital twin refers to creating a richer and more interactive form of memory by bringing together various information about the deceased's life, behavior, interests and achievements (photos, videos, audio recordings, letters, social media shares, etc.).

Through the ICT capabilities, primarily the Internet, it is possible to more effectively implement the digitization of cemeteries, the collection and preservation of information about deceased people. The concept of a digital cemetery is important from the point of view of storing and protecting information about deceased people. The implementation of this concept requires solving the following issues:

Accessibility and authentication. In terms of data privacy, the security of personal data of deceased people should be ensured (password-protected information, authentication issues, etc.).

Inheritance. Due to the lack of a clear legal basis, the issue of inheritance of personal data of the deceased remains unresolved. It is uncertain how to handle the issues such as deleting or protecting data, which should be public or private.

Technologies used and finance. Over time, the advance of Internet technologies and the emergence of new intelligent systems will require the digital cemetery system to be changed, improved, and more experienced specialists, which means additional financial costs.

Political platform and law. Gaps in the laws on funerals and cemeteries should be eliminated. There should be a law on the protection of personal data of the deceased. Laws on holding funerals and protecting cemeteries should be improved.

3.4. Demography of mortality

As a result of the influence of ICT, demography is being integrated into other scientific disciplines, and due to the intersection of these sciences, new scientific fields have emerged, such as "demography of education", "medical demography", "linguistic demography", "demography of crime", "economic demography", "social demography", "ethnic demography", "political demography", demography of mortality", etc.

Demography of mortality is not an isolated field, but an integral part of demography (Roberts et al., 2003). The analysis of graves and deaths is important for understanding the past, present and future of the population, identifying social and economic inequalities, developing effective policies and improving the quality of life of people at all stages of the life cycle. Mortality indicators are a key component for creating complete demographic models and forecasts.

Demography of mortality is closely related to all other areas of demography, since death is an integral part of the life cycle and has a significant impact on the structure and dynamics of the population as a whole.

The impact of demography of mortality on other areas is given below:

Demography of education examines the state of education in a country and in individual regions, and the demographic factors (migration, mortality, etc.) affecting the quality of education (Perla et al., 2021). Demography of mortality is related to education through the analysis of the impact of educational level on life expectancy and causes of death. Education can affect health awareness,

lifestyle, and health services.

Medical demography analyzes which diseases are most prevalent in a country, the health level of the population, the state of healthcare in the country, the distribution of diseases by region, etc. Medical demography is also important in solving the distribution of doctors by region and many other issues (Girosi et al., 2007). Medical demography studies the distribution of health and diseases among the population and the factors affecting health. Demography of mortality is a key element of medical demography, as it studies the causes of death, the age of death from various diseases, the impact of medical interventions on the mortality rate, and life expectancy. Mortality analysis helps to evaluate the performance of health systems, identify priority areas for medical research, and develop public health strategies. In other words, demography of mortality provides basic information for assessing the burden of disease, the effectiveness of treatments, the impact of epidemics and pandemics on mortality, and for planning health resources and services.

Linguistic demography determines the total number of speakers of a given language in a country, the interests and problems of people according to the state of the language and the way of expression (Kleinow, 2015). The analysis of the linguistic features of death certificates, wills, and other documents can provide information about language, dialects, and sociocultural changes in the past. Language plays an important role in the expression of grief, funerals, and the preservation of the memory about the deceased. The analysis of the linguistic features of death among migrants can provide insight into their integration process and the impact of the linguistic environment on health and life expectancy. Studying the language used by the deceased in their online profiles and messages is a key part of preserving their digital memory.

Demography of crime studies the relationship between crime and the demographic characteristics of the population, and is used to address issues such as the criminal situation in a country, which regions are more prone to crime, the classification of criminals by age categories, the determination of the relationship between demographic factors and criminal events, etc. (Li et al., 2005). Demography of mortality studies the impact of demographic factors on the commission of crimes resulting in death.

Economic demography studies the relationship between economic factors and demographic processes. Demography of mortality affects the economy through changes in the population with working-ability, health and social security expenditures (pensions of population, funeral benefits), inheritance, and wealth assignment. Analysis of mortality by socioeconomic group can reveal economic factors affecting the causes of death.

Social demography studies the impact of social factors on demographic processes. Demography of mortality are closely related to social aspects such as education, marital status, social support, lifestyle, and access to health services, which can significantly affect mortality risk and life expectancy.

Ethnic demography studies the demographic characteristics of different ethnic groups. Demography of mortality analyzes mortality rates and causes in different ethnic communities, identifying specific risks related to lifestyle, genetic predisposition, access to resources, and sociocultural factors.

Political demography studies the impact of demographic processes on politics and public administration. Demography of mortality affects health, social security, pension and funeral planning policies.

In this context, it is important to create an e-register of deceased persons, i.e., a digital burial system, as part of the population register. With the creation of such an e-register on the e-government platform, it will be possible to obtain accurate information about the geography of the places of death, GIS coordinates, etc. of deceased persons and conduct their demographic analysis.

The digital burial system can facilitate the transition from traditional census to online census and conduct various socio-demographic studies at the national, regional, local and individual levels, being an information source and analytical center for mortality prediction.

3.5. Electronic register of deceased persons

To facilitate demographic studies and obtain a reliable data source, each state should have a single national population register (National Population Registers), which collects all demographic and personal data. In order to establish a state population register in Azerbaijan, the Law "On the State Population Register of the Republic of Azerbaijan" was adopted in 2006 (e-qanun.az, 2006). This Law envisages the creation and use of the State Population Register of the Republic of Azerbaijan (SPRRA) using the latest achievements of information technologies. It also determines the organizational and legal foundations for the protection of personal data.

The Law states that "Information in the State Register is stored permanently and cannot be destroyed under any circumstances". SPRRA is of great importance for the study of death, birth and migration processes in the country. The State Register is an authoritative data source for the data analytical systems of both state and private companies. Based on the existing infrastructure of the SPRRA and e-government, it is possible to create an environment that would collect all structured and unstructured information about deceased people.

The e-government concept is very suitable for creating a technological environment that collects interrelated information stored in various data systems into a single system (Arulnathan et al., 2023). It offers wide opportunities and equipment for combining various registries into a single national infrastructure.

The main goal of creating the State Register of Population is to ensure the formation of the country's information and legal space, register legal acts and other documents in order to promptly obtain the necessary legal information, and create an electronic data bank (Chircu et al., 2023). This system is also important for the implementation of national projects, the provision of state and municipal services, targeted social support, and the fight against legal violations and fraudulent acts.

SPRRA collects information about citizens of the country, foreign citizens living in the country but without citizenship, and citizens of the country living abroad. This service aims to register personal information about citizens, provide necessary services to citizens by state bodies, and generate data to ensure the protection of citizens' rights.

SPRRA contains personal information about citizens (surname - previous and after change, name and patronymic, date and place of birth, place of residence, location, citizenship, about the deceased - date and place of death, burial place) and various additional documents. Many additional documents may include the series of an identity card or passport, legal documents representing information about the citizen's activities and social status (tax, medical, social insurance, etc.) (e-qanun.az, 2006).

An entry is formed in the register about each person, and each entry is numbered with a special identification number. In most countries, a unique personal identification number (PIN) is used to simplify identification (Arulnathan et al., 2023).

The Law on the State Register of Personal Identification Numbers (PIN) defines it as follows: "Personal identification number - a unique code issued in a prescribed manner to a person whose information is entered in the State Register and allowing for the unambiguous identification of relevant information about the person". PIN is a string of numbers or alphanumeric characters used to authenticate a citizen to the system. The information collected in the register is grouped by identification number.

The entry in the register cannot be destroyed or changed. If changes are required to the entry, the previous entry is not deleted, but is stored with the date of change. When a citizen dies or is declared dead by a court, the PIN is not reused, but archived (Das et al., 2009). The availability of such a rule creates the opportunity to ensure the reliability of collecting all documents and information related to a citizen even after his/her death. Moreover, the SPRRA can ensure the effective functioning of the digital cemetery portal by collecting and analyzing information about deceased people.

The rules for using or familiarizing with information stored in the State Register of Population are represented in the law on personal data of each state. Linking the State Register of Population with the digital cemetery project can ensure that information about deceased people is obtained from a more reliable source. The subsequent use of the PIN code of the deceased in the digital cemetery project can be important in ensuring identification and information security. That is, the grave of the deceased can be provided with the GPS and linked to the PIN of the deceased.

If the information about a citizen stored in the e-government registry during his/her lifetime is stored in the database in the form of a record under a PIN, then after his death the citizen can be virtually linked to his/her burial place. In Azerbaijan, the registry of cemeteries is maintained by the State Committee for Work with Religious Organizations of the Republic of Azerbaijan, and linking this registry with the SPRRA can form the basis of the concept of a digital cemetery.

3.6. Digital twin

Collecting information about people in the database of a digital cemetery can be important for reviving that person in a virtual environment that is, creating a digital twin of that person. A digital twin has all the capabilities to create an accurate model of a person (Das et al., 2009). A digital cemetery is a digital twin of the deceased, that is, a model representing a visual image of the deceased. In other words, using the capabilities of

a digital cemetery, we can create a digital avatar.

The main goal of creating a digital avatar model is to commemorate the deceased, to help them be respected by their relatives and society, and to keep alive historical figures that are considered the national spiritual heritage of the people. The use of advanced information technologies, including intellectual systems, allows for the visualization and modeling of people who are living or no longer in the physical world (Das et al., 2009).

To model a digital twin of a deceased person, first of all, his/her behavior, interests, and related demographic processes should be studied. A digital twin of a person can be generated regardless of whether that person is alive or not.

A digital twin of a person is closely related to demographic modeling. A demographic model refers to all statistical, mathematical, and predictive models used to study demographic processes and human behavior and obtain a logical explanation (Zhang et al., 2023). In most cases, certain social processes affecting people's lives are displayed in demographic modeling.

With big data and cloud technologies, the Internet of Things, and cyber-physical systems, many important issues that concern society today can be solved through the capabilities of artificial intelligence.

For example, efficient management of labor resources, security of the state's information space, prevention of criminal incidents, the impact of social media on people's behavior and daily life, logical explanation and prediction of social processes, etc. are being solved today with the use of intelligent systems (Chen et al., 2012, Zerkouk et al., 2019).

The fourth industrial revolution (Industry 4.0) includes all the possibilities for creating a "Grave 4.0" environment. The concept of a virtual grave is one of the trends of Industry 4.0, it is a virtual cloud precisely built on the basis of all possible information about the deceased.

The Grave 4.0 environment is constantly gaining new opportunities with the application of artificial intelligence to upsurge the efficiency of the process of creating a virtual profile of the deceased. Methods based on data mining algorithms are an integral part of big data analysis. They ensure the successful implementation of the digital cemetery concept, obtaining new knowledge in the analysis of cemeteries, and increasing the efficiency of research.

In view of the digital cemetery capabilities, we can consider it as a cyber-physical system. The main sources of data analyzed in the digital cemetery system can be search queries in web browsers, social media, cemeteries equipped with sensors, and various e-registries (fig. 1).

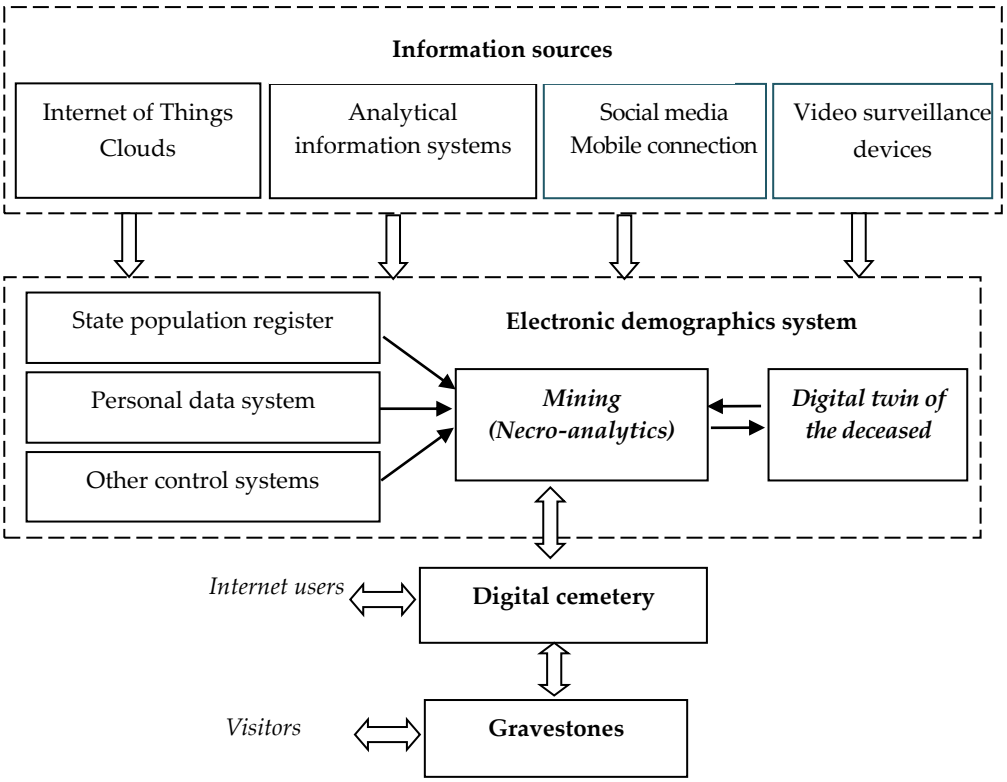

Fig. 1. General structure of the digital cemetery system

Today, information obtained from graves equipped with sensors can be important for the cemeteries' protection, determining the grave location, whether the geographical location of the cemetery is successful from the point of view of urban planning, etc. The digital cemetery system allows for a comprehensive analysis of information about cemeteries.

3.7. The role of digital cemeteries in the protection of the national cultural heritage of Azerbaijan

The accurate registration of cemeteries is necessary for their protection as a material, spiritual and historical heritage, conducting various analyses, transferring necessary knowledge to the future and the younger generation, etc. The enemies attempting to occupy the lands of Azerbaijan, falsify its history and culture and erase it from people's memory are destroying and removing cemeteries remaining in the territories of neighboring countries, which prove that Azerbaijanis have lived in those places since ancient times. In order to preserve the blood memory and history of the Azerbaijani people, it is possible to guard them in a virtual environment by creating a virtual model of these cemeteries.

The necessary measures for the restoration of destroyed cemeteries should also include the generation of digital cemeteries. Since these projects are open, people can directly access the web pages of these projects from a browser and upload valuable information (photos, videos, audio recordings, etc.) stored in their memories and archives there, which will enrich information about the deceased and make it always accessible. In this regard, the creation, launch and expansion of portals such as nekroloq.az, mezarliq.az, memorial.az in Azerbaijan may be imperative for the implementation of the "Digital Cemetery" project.

The "Digital Cemetery" project also provides new opportunities for online mourning ceremonies. In order to prevent the spread of Covid and other epidemiological diseases, it is more appropriate to hold mourning ceremonies virtually. Emergencies and wars also necessitate this type of mourning ceremony.

Conducting mourning ceremonies virtually is vital for the effective solution of the following issues:

- traffic jams;
- eliminating waste in mourning ceremonies;
- taking into account financial issues;
- geographical locations of ceremony guests;
- saving time for those who want to attend the ceremony and etc.

There is a great need for the widespread promotion of BillionGraves, rahmat.az platforms and other world-renowned digital cemeteries in our country, especially attracting young volunteers with IT skills. Entering information about the graves of our fellow citizens buried in our ancient homelands into these systems and integrating them with various projects such as the e-demography system, the National Toponymic Geoinformation System (Alguliyev et al., 2022) on the e-government platform will ensure the following prospects:

- Digital cemeteries can ensure people eternal life;
- They can produce a general picture of the historical areas inhabited by different peoples and ethnic groups;
- They can increase knowledge about which peoples belong to which territories and states;
- They can create new opportunities for studying, evaluating society, and predicting social processes;
- They can provide rich material for research in various fields of science (medicine, history, archeology, etc.);
- They can identify and restore historical ties between generations;
- They can ensure closeness and tolerance between peoples by serving to preserve national and spiritual memory.

4. Discussion

Registering each grave in the state register and providing it with GPS can prevent opacity related to the burial process. Linking headstones to GPS can ensure that visitors can easily find the grave they want to visit in cemeteries. Obviously, finding the right grave in large cemeteries, regardless of the country in the world, is not an easy task, and without a guide, it takes hours. Some cemeteries are centuries old, so finding the location of old graves can be more difficult process.

The study showed that accessibility of digital cemetery and the opportunities it offers further increase its importance. Significance of the digital cemetery concept can be defined as follows:

1. A digital cemetery is a project that includes information about every citizen, regardless of their status in society, preserves their memory and prevents them from being forgotten.

2. A digital cemetery can be decorated with flowers (virtual flowers) as in ordinary cemeteries, and poems and heartfelt words can be written on a virtual headstone. Virtual cemeteries are also a place where those who are familiar with the deceased gather and share information.
3. A digital cemetery ensures moral support for the relatives of the deceased from the community, somewhat alleviating their grief.
4. Cemeteries are represented on digital maps, land ownership management becomes easier, and the quality of e-services increases.
5. Digital cemeteries are important for strengthening society, shaping new relationships, and strengthening ties between relatives.
6. Mapping cemeteries and accurately determining the geographical location of each grave are imperative issues. This helps visitors to accurately determine the location of their loved ones and organize funerals appropriately. The process of digitizing these maps and transferring all information about graves to the database is already underway.
7. Digitization of cemeteries allows researchers to conduct better research on burial sites and the buried, as well as collect and expand historical information about graves for future generations. In other words, the digital database of cemeteries ensures effective mapping of cemeteries and research about the deceased.

5. Conclusion

Industrial Revolution is expanding, the concept of a digital cemetery can be further improved with new technologies and ideas, become popular and turn into one of the main projects of the Internet. The implementation of a digital cemetery project on the e-government platform is important as important trends of e-services for citizens. A digital cemetery entails that people exist in a virtual environment even after death, live virtually and information about them is not forgotten. Every person has the right to be in a virtual environment after death, even if they are not physically in this world. This opportunity can be given to them by their living relatives and friends through the digital cemetery project.

The study revealed that various measures are being taken and projects are being developed in the world to protect cemeteries and prevent the loss of information about the deceased.

Despite the approval of the "Rules for the Construction and Management of Cemeteries" in Azerbaijan in 2018, certain problems regarding cemeteries still remain. The problems of not preserving most cemeteries, selling graves, losing information about the deceased over time, etc. are relevant. Studies also showed that digital cemeteries, in addition to preserving and analyzing information about deceased people, solve the problem of burial places. Purchase of graves has led to the emergence of a black market for cemetery land. Funerals have become an additional source of income in some religious communities. Digital cemeteries are of particular importance in ensuring transparency in this area and eliminating corruption and fraud.

Digital cemeteries are a type of e-services created for citizens. Consequently, through the digital cemeteries service, the selection of a cemetery, burial place, and procedures related to burial (obtaining a death certificate, holding a funeral ceremony, etc.) should be included in the e-service.

Digital cemetery also ensures the implementation of operational measures against illegal seizure of graves, their relocation and destruction without the permission of relatives. It also allows for accurate registration of the transposition of graves for certain reasons, and facilitates the identification of the remains of the deceased.

The concept of digital cemetery can make the collection, preservation and analysis of information about the deceased important for the effective functioning of the digital cemetery portal. Collecting and preserving information about the deceased in a digital cemetery means not only presenting respect to the deceased, but also preserving history and national and spiritual heritage. So that people do not forget their ancestors, they pass on their knowledge to future generations by properly using the opportunities created by advanced information technologies. Specifically, the creation of "digital cemetery" web resources is of great importance in the protection of both history and national and spiritual heritage. The integration of these resources into global Internet cemetery resources opens up vast opportunities for recognizing nations and the prominent figures that represent them and have passed away.

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