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Compilation of Avatar Development Roadmap in Iranian Banking with the Life Cycle Approach of System Development and Human-Computer Interaction

Amir Bahador Morovat [1*], Farhad Nazari Zadeh [2], Ahmad Haghiri Dehbarez [1]

[1].Department of Industrial and System Studies, Eyvanekey University, Semnan, Iran
[2].Department of Industrial Engineering, Malek Ashtar University of Technology, Tehran, Iran

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Abstract

The spread and use of emerging technologies have led to a significant transformation in the banking industry and has created widespread changes in the relationship between customers and banks. These changes have led to avatars, previously seen in Hollywood movies, entering the banking sector and are now used as useful tools for providing services to bank customers. Considering the move of Iranian banks towards the adoption of emerging technologies and the willingness of these banks' customers to use these technologies, this research outlines the roadmap of avatar technology in six stages of requirements gathering and analysis, system development, system implementation and coding, testing, deployment and system operation and maintenance, utilizing the expertise of 11 researchers from private and public banks as well as IT and information technology specialists in Iran. In addition, at each stage of the roadmap, the focus has been on customer satisfaction and improving the quality of avatars through human-computer interaction approaches. For this purpose, an estimated timeline of 37 to 49 weeks has been proposed for the roadmap, which describes the necessary actions for each stage, along with possible challenges and issues. What is certain is that the implementation and use of avatars in the Iranian banking industry requires short-term, medium-term, and long-term strategic planning to enable the use of this technology, according to the proposed strategic roadmap.

Keywords: Avatar; AI; Machin Learning; Roadmap; System Development Life Cycle (SDLC); Human-Computer Interaction (HCI).

1- Introduction

The rapid diffusion of digital financial technologies has reshaped value creation and service delivery in banking, pushing institutions toward conversational, always-on interfaces. Among these technologies, avatar-based agents have emerged as a credible vehicle for human-like interaction, personalization at scale, and operational efficiency in front-office and self-service channels [1]. Early adopters report gains in customer engagement and process throughput when avatars are embedded in well-designed service journeys [2, 3].

Despite global advances, avatar deployments in the Iranian banking sector remain limited and largely experimental. Implementations are often interface-centric rather than life-cycle-centric, with insufficient alignment to regulatory, cultural, and infrastructural particularities of domestic banking [4]. This situation elevates the need for a structured, bank-ready roadmap that goes beyond UI novelty to govern requirements, risks, and organizational integration [5, 6].

Prior studies discuss avatars across marketing, virtual environments, and interface design; however, they seldom integrate system development methodologies with user-experience principles for banking contexts. The literature lacks a comprehensive, stage-based roadmap that connects requirements engineering, design, implementation, evaluation, and governance of avatar systems in banks—particularly under Iranian constraints (e.g., data governance, language, service norms) [7, 8]. This gap motivates the present research.

This paper contributes a technology roadmap for avatar implementation in Iranian banking that integrates the System Development Life Cycle (SDLC) with Human–

✉ **Amir Bahador Morovat**
Amir.bahador.19197@gmail.com

Computer Interaction (HCI). Unlike works centered primarily on interface aesthetics or isolated pilots, we articulate bank-grade stages, deliverables, and decision gates that couple user-centered design with enterprise concerns (risk, compliance, and scalability). The roadmap offers actionable guidance for executives and designers while extending the academic discourse on avatarized financial services [9, 10].

Accordingly, we address: How can a comprehensive, user-centered roadmap for avatar technology be designed for the Iranian banking industry to guide end-to-end development and deployment? We aim to specify stages, artifacts, and gates that connect business needs, user requirements, and technical implementation, ensuring regulatory compliance and measurable service outcomes [11, 12].

Our methodological stance derives explicitly from SDLC—to structure complex technology programs—and HCI—to ensure usability, accessibility, and adoption. SDLC supplies the staged governance (from requirements to maintenance), whereas HCI contributes evidence-based principles for interaction design and evaluation[13]. Their integration aligns technical feasibility with human factors throughout the project life cycle.

To enrich analytical rigor in later sections, we propose the following testable propositions that align with our roadmap:

- P1/H1: Adherence to SDLC gates combined with HCI evaluation will be positively associated with customer satisfaction with avatar interactions.
- P2/H2: Organizations that embed user-research insights into requirements and prototyping will achieve higher task completion and containment in avatar channels
- P3/H3: Roadmap-guided deployments will show improved operational efficiency (e.g., shorter handling times) compared with ad-hoc deployments [2, 9].

In addition to addressing an existing gap in the Iranian banking literature, this paper uniquely contributes by presenting an integrated, stage-based roadmap that systematically combines system development methodologies with user experience principles for the first time in this context. The proposed framework offers actionable, locally relevant guidance for banking executives and technology implementers while advancing the academic discourse on technology-enabled service design.

In the subsequent sections of this paper, the research literature and background of avatar technology in financial services are discussed first. Next, a detailed framework is presented integrating the System Development Life Cycle (SDLC) and principles of Human-Computer Interaction (HCI) for the systematic development of avatars in Iranian banking. Each stage of the roadmap is then elaborated with practical actions, challenges, and user experience requirements. Following this, the results and analytical findings are discussed to highlight the practical and comparative aspects of the proposed approach. The paper concludes with a summary of innovations and research achievements, together with a dedicated section offering detailed recommendations for future research directions.

2- Literature Review and Research Background:

2-1- Research Literature:

2-1-1- Avatars: Concepts, Types, and Uses

The term avatar has been framed across multiple traditions—from visual stand-ins and embodied agents to adaptive, context-aware service representatives. [14, 15]. Conceptualizations typically span:

1. visual/representational definitions;
2. contextual/locational accounts across media and cyberspaces;
3. historical/linguistic roots;
4. marketing and identity framings as replicas or personae;
5. temporal/interactivity considerations distinguishing synchronous vs. asynchronous mediation [16-18].

Avatars are now documented across industries—gaming, tourism, education, and public services—gradually converging on service co-production with humans in digital channels [19, 20].

2-1-2- Avatars in Financial Services

In banking, avatars serve as frontline conversational agents, onboarding assistants, and advice companions, mediating tasks such as KYC prompts, eligibility checks, and product guidance. Studies note measurable improvements in engagement, perceived social presence, and guidance quality when avatar behaviors and scripts reflect user intent and financial literacy levels [21,22]. Technology-roadmapping work in adjacent sectors likewise emphasizes staged capability maturation and governance for safety-critical or regulated environments [23-25].

2-1-3- Iranian Context and Early Implementations

Domestic deployments in Iran—often inspired by media mascots and public-sector information campaigns—illustrate cultural receptivity to character-based communication, yet bank-specific avatar programs are scarce and typically UX-led rather than life-cycle-managed [2, 12].

Sectoral surveys highlight infrastructure constraints, language/voice design, and regulatory alignment as pivotal to scale-up [6, 26]. Broader work on persuasive and identity-laden digital characters also signals effects on trust, attention, and purchase intention—implications that banking avatars must responsibly harness [27, 28].

2-1-4- System Development Life Cycle (SDLC)

The SDLC provides a disciplined, stage-based pathway—requirements, design, implementation, testing, deployment, maintenance—supported by decision gates and artifacts that mitigate scope creep and integration risk. Variants (e.g., Waterfall, Iterative, Agile) can be adapted to compliance-heavy banking environments where auditability and change control are essential [29,30]. Prior roadmapping research underscores the value of capability staging and traceability of decisions across the program timeline [46-48]. In our work, SDLC anchors the technology governance of avatar projects [31, 32].

2-1-5- Human–Computer Interaction (HCI)

HCI contributes principles and methods—user research, usability heuristics, accessibility, prototyping, and empirical evaluation—that ensure avatar systems are intuitive, inclusive, and trustworthy. Evidence links HCI-informed design to higher task success, perceived usefulness, and adoption in information systems [48, 49]. Classic and contemporary HCI sources provide foundations for evaluation protocols later employed in our roadmap (e.g., scenario-based testing, think-aloud, SUS-like metrics) [53].

2-1-6- Integrating SDLC and HCI for Avatar Programs

A gap in the literature is the systematic integration of SDLC governance with HCI evaluation for avatar deployments in banking. Existing studies tend to optimize one dimension at a time (e.g., interaction design) without codifying life-cycle artifacts (requirements baselines, UX evidence repositories, acceptance criteria) that carry through to deployment and maintenance [36-38]. We address this by mapping HCI activities onto SDLC stages—ensuring every gate is informed by user evidence and that design intents persist into production and evolution [39, 40].

2-1-7- Positioning vis-à-vis Prior Studies

Compared with prior works that report pilot-level experiences or interface prototypes [21,41], our contribution is a bank-grade roadmap with explicit stage definitions, artifacts, and evaluation hooks that bind user-centric evidence to enterprise risk and compliance controls. This synthesis clarifies where earlier contributions inform our approach (e.g., social presence effects, script design) and where we extend the state of practice (e.g., gate criteria, organizational readiness). This framing prepares the ground for a subsequent discussion section where we will compare our results to similar studies in detail.

2-1-8- Implications for Methodology

The review justifies two design choices in our method: (i) adopting SDLC to manage complexity, traceability, and compliance; and (ii) embedding HCI throughout to safeguard usability and adoption. These choices shape our research propositions (H1–H3) and the evaluation checkpoints later used to qualify the roadmap's effectiveness in banking settings [31, 26, 42].

2-2- Research Background:

Previous studies have shown that the use of avatars improves user experience; however, most existing studies have focused on designing avatars for entertainment or marketing purposes in general, and few studies have examined the use of avatars in the banking field.

Ahmadzadeh, Tabataba'ian, and Shahrestani conducted a study in 2022 to investigate the effect of avatar characteristics on customer identification and purchase intention, with the mediating role of customer involvement in the metaverse. The statistical population of the study was the millennial generation and those born after that in the city of Isfahan. Due to the unlimited statistical population, 384 people were considered according to the Greggsy and Morgan table. The results of the study showed that the mental ability, social skills, athletic ability, artistic/musical ability, and physical attractiveness of the avatar have a positive and significant effect on customer identification. Also, customer identification has a positive and significant effect on customer involvement, customer involvement on purchase intention, and customer identification on purchase intention [28].

In a study based on a theoretical framework of avatar anthropomorphic realism, nonverbal social cues, the eye-mind hypothesis, and interaction process analysis, Lee et al. (2025) examined the effect of avatar gaze behaviors on users' attention allocation and perception. They showed that both avatar gaze type and interaction type significantly affected participants' attention allocation. Natural gaze behavior and task interactions reduced the general pattern of gaze avoidance observed in previous studies. This research emphasizes the importance of the gaze and type of interaction of avatars [39].

In a study conducted by Torabi, Hassangholipour, Yasouri, and Jafari Zare in 2021, the conceptualization and presentation of the avatar marketing model in Iran was discussed. This qualitative research, which is based on the data-driven technique and the Strauss and Corbin approach, was conducted through library studies and semi-structured interviews. The statistical population in this study was experts who, as full professors or associate professors, had many years of teaching experience and were familiar with the new concepts of marketing management and art. The sampling method was also purposeful snowball sampling. The findings of this study identify the main characteristics of avatars in marketing, which are based on two factors:

behavioral realism and visual realism for consumer understanding. They then outline the avatar marketing model with 368 concepts and 38 categories based on six dimensions: causal conditions, context, intervention, main phenomenon, strategies, and consequences. The results of this study indicate that avatars can increase accuracy and precision in customer contact by simulating human behavior in marketing using data science and artificial intelligence, and provide positive and competent performance in unplanned situations and processes to promote the marketing of products and services [41].

Lam (2025) examined the ethical implications of using avatars and virtual reality (VR) in education, focusing on issues such as privacy, identity representation, psychological impact, equity of access, and cyberbullying. This paper proposes stronger and more comprehensive ethical guidelines by integrating Confucian ethics with contemporary ethical frameworks, including epistemology, utilitarianism, and virtue ethics. The holistic approach of Confucian ethics ensures respect for students' identities, mental well-being, and equitable learning opportunities. Ultimately, fostering a culture of virtue, respect, and inclusion can lead to a more ethical and harmonious educational landscape through the responsible use of educational technology. Finally, legal and regulatory approaches to overcome existing challenges are reviewed and examined [40].

In 2024, Bing Hu presented an avatar-based framework for integrated customer identification in banking systems using artificial intelligence and generative graph neural networks. Hu believes that models enhance existing data sets and ensure the completeness and accuracy of customer profiles, so in his proposed model, neural networks are used to simultaneously model complex relationships and interactions in customer data, capture complex dependencies, and increase the accuracy of customer identification. The researcher states that the proposed framework offers significant benefits, including improved regulatory compliance, increased operational efficiency, and superior customer experience. The research also notes that by providing a unified view of customer data, financial institutions can better detect and prevent fraudulent activities, meet stringent regulatory requirements, and provide personalized services. Government regulatory departments can more effectively manage public funds and ensure transparency. Third-party service providers can use customer profiles to better provide services and manage risk [12].

In 2024, Silva and Campos, relying on the TCCM framework, conducted a systematic literature review of research conducted on avatars in reputable journals between 2005 and 2022. This study examines the historical development of the avatar topic, both theoretically and methodologically, examines the key factors involved in avatar marketing strategy, and considers the reasons for studying and using avatar marketing. Finally, an attempt has been made to develop an integrated conceptual framework, a conceptual range of avatar marketing concepts, and to help provide a unified concept for avatar marketing [43].

Miao et al, in 2022 addressed the emerging theory of avatar marketing in a study. In this study, the conceptual and key elements of the term avatar are identified and critically evaluated, and a definition and typology of avatar design elements are presented. The alignment of avatar form realism and behavioral realism among different possible cases, and the effectiveness of avatars, are also examined. Finally, the researchers present an emerging theory of avatar marketing by triangulating insights from the essential elements of avatars, a combination of existing research and business practices. This proposed framework considers key theoretical insights, research propositions, and important managerial concepts for this expanding field of integrated marketing strategy and outlines a research agenda to test the propositions and insights, as well as to advance future research [14].

Although research on avatars has expanded, especially since 2005, attention to this issue has been focused more on topics such as computer games and marketing-related topics. In domestic and foreign research, the concept of avatars in the banking industry and the provision of a roadmap for the use of this technology in the banking industry have not received much attention. Additionally, previous studies have mainly focused on the technical and design aspects of avatars, while human-computer interaction (HCI) and system development life cycle (SDLC) requirements have been less studied. This study fills this gap by providing a comprehensive roadmap and framework for the development and implementation of banking avatars in Iran. Unlike previous studies that have focused more on the marketing and digital interaction aspects of avatars, this study is the first to provide a comprehensive roadmap for the development and implementation of banking avatars in Iran. The combination of the two approaches, SDLC and HCI, in this context has provided a scientific and practical framework for the deployment of this technology in the Iranian banking industry.

3- Research Method

The present research is a descriptive study based on epistemology and future planning of the technology space, and it was conducted based on the opinions of experts and their consensus. For this purpose, a panel of 5 experts active in the field of financial industry technologies was initially formed, and according to the experts' opinions, the system development life cycle approach and the human-computer interaction approach were selected as the methods for drawing the technology roadmap.

To create the technology roadmap, unstructured (in-depth) interviews were conducted with 11 experts in the field of new financial technologies who had at least a master's

degree in fields related to new financial technologies and more than 15 years of experience in banks or financial service companies. These experts were purposefully selected. Prior to conducting the interviews, the results of library studies on avatars, the system development life cycle approach, and the human-computer interaction approach were shared with the interviewees. Individual interviews were then conducted with each expert.

Before starting the interviews, the scope and context of the problem were explained to the experts by the researcher. Four sessions were held with each expert at approximately one-month intervals, with questions raised about each stage separately. Each interview lasted 45 to 70 minutes. The number of interviews was based on a saturation pattern, and the content analysis method with open coding was used to analyze the interviews. At each stage, the concepts from library studies were also used to complete the stage. At the end, a roadmap was compiled for validation and approval by each of the 11 research experts, and their corrective points were considered.

According to the Expert Panel, the system development life cycle approach was considered for drawing the technology roadmap, and the waterfall model was chosen among the various existing models. The waterfall model is simple, methodical, and easy to understand and implement. It works well and produces correct results. The main advantage of the waterfall model for the system development life cycle is that it provides a structure for organizing and controlling a system development project. However, the most important methodological requirement in this approach is the accurate identification of user needs [26]. Due to its regular and linear structure, this model is suitable for large and complex projects such as avatar development. In general, the waterfall model of the system development life cycle has six stages as follows:

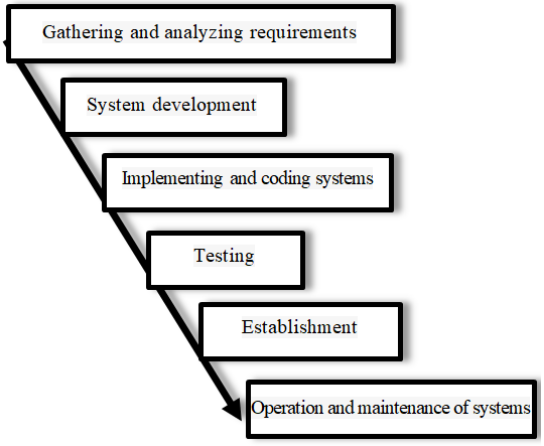

Fig. 1 Stages of the waterfall model in the system development life cycle [49]

Another approach in this research is human-computer interaction, which deals with how humans and computers communicate and examines the principles of designing, evaluating, and implementing interactive systems with the aim of creating a user-friendly and effective experience. There are various models for describing and analyzing human-computer interaction, each focusing on specific aspects of this interaction. The user experience (UX) model was used to draw a technology roadmap in the Iranian banking industry. This model, focusing on the user, improving customer satisfaction, and achieving the goal [42], is considered a suitable option for drawing an avatar technology roadmap. In addition, this model is compatible with the waterfall method of the system development life cycle. The user experience model focuses on strategy, scope, usability structure, and visual values. While describing each of the components, the research experts were asked to pay attention to each of the six stages of developing a technology roadmap in applying these items. Fig 2 presents a diagram of the research process.

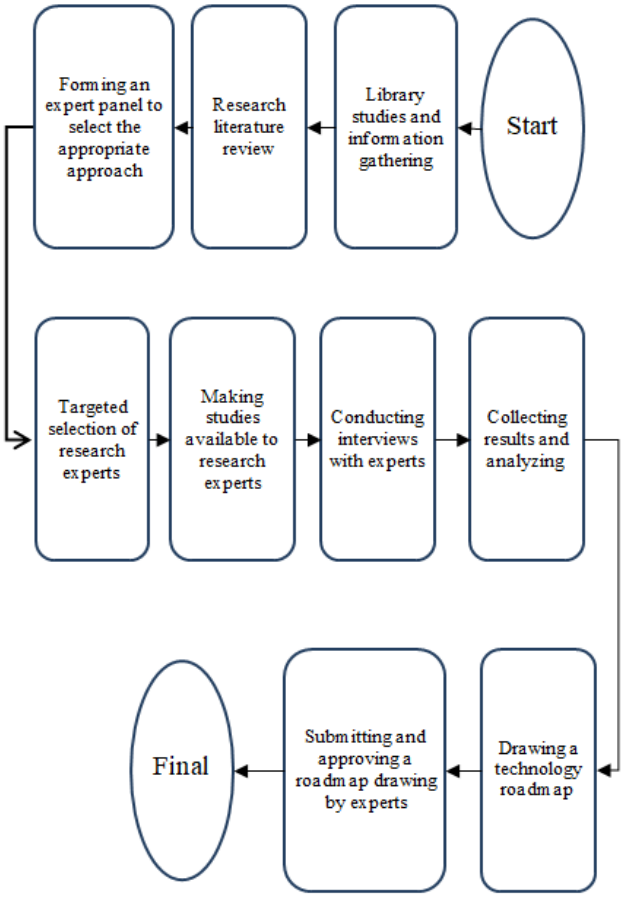

Fig. 2 Research implementation process

4- Implementation Steps:

In this research, the avatar technology roadmap has been drawn according to the six-step approach of the waterfall model of the system development life cycle. According to the opinions of research experts and library studies, the actions required at each stage and the existing challenges, along with the proposed duration, have been considered. Additionally, the human-computer interaction user experience approach has been addressed at each stage.

4-1- Requirement's Collection and Analysis:

According to the research experts, this stage is considered one of the most important stages of drawing the avatar technology roadmap in the banking industry because the results obtained from it will be used in the later stages of the project. Additionally, with a detailed analysis, it is possible to identify customer needs and the technical limitations of the bank and take action in designing an effective and compatible avatar.

Avatars can be used as powerful tools to solve many common customer problems and improve user experience. One of the basic needs of bank customers is addressing questions and ambiguities regarding receiving services or carrying out financial transactions (questions about the conditions of the facilities, how to transfer, etc.), which typically involve visiting bank branches and standing in queues or calling support centers and spending time waiting for expert responses. While meeting this need will be easily resolved through avatars, avatars can quickly understand complex questions and provide accurate answers 24/7 from different portals (branch, mobile banking, internet banking) using natural language processing algorithms. They can act as smart assistants, helping customers quickly find the information they need.

Avatars can help customers perform simple transactions such as transferring funds, paying bills, etc., and act as financial advisors to help customer's select appropriate products and services. Additionally, by using a simple and smooth user interface, avatars can make the transaction process easier for customers. In cases where access to bank branches is not possible, avatars can act as virtual branches, allowing customers to access banking services at any time and place, thereby increasing customer satisfaction and productivity for the bank.

Other important considerations at this stage include analyzing and identifying customer behavior patterns and paying attention to different groups of bank customers. Factors such as the desire to visit bank branches in person, uncertainty about the security of technologies, lack of awareness among some bank customers, and, in some cases, the costs of using technologies like avatars are crucial in determining customer behavior patterns. By identifying these patterns, it is possible to define various user personas, accurately identify the needs of each customer group, and design a simple, intuitive, and understandable avatar for all customer groups and every age group. Additionally, identifying customer behavior patterns in designing conversations is effective in gaining customer trust and providing personalized services to customers.

For example, a young customer may seek fast, efficient, and online banking services and be interested in new technologies. A middle-aged customer may seek financial advice and require accurate and reliable information. An elderly customer may seek simple and understandable services and need more help using an avatar. Addressing these issues will increase the acceptance of avatar technology by bank customers, improve user experience, reduce costs by automating many processes, and increase revenue by providing better and personalized services.

By examining the above issues, it is possible to identify the capabilities required by the avatar, such as answering frequently asked questions, guiding customers in performing simple transactions, or authenticating identities. These capabilities can be designed based on a needs analysis and a review of customer behavior patterns.

Another important issue at this stage is identifying the existing infrastructure necessary for avatar technology in the bank. The use of avatar technology in banking requires various technologies, such as natural language processing, speech recognition, machine learning, artificial intelligence, virtual and augmented reality, user interfaces, and cybersecurity. The existence or use of these technologies should be considered for the implementation of avatar technology. Additionally, the availability of a suitable infrastructure for different communication channels to provide avatar services, the data and information infrastructure available in the bank, and the possibility of integrating avatar communication with the existing infrastructure in the bank are factors that should be considered. Addressing challenges such as customer acceptance of technology, along with the appropriate and required infrastructure, can contribute to the successful implementation of the project.

Considering the human-computer interaction approach, user research and understanding are important. Identifying the needs, goals, and different behaviors of users through tools such as interviews, questionnaires, and observations can help us gain better insights. Additionally, drawing a user journey map at this stage can be valuable, as it outlines the user's interaction path with the avatar from beginning to end. This map helps us identify user touchpoints with the avatar and pinpoint weaknesses and opportunities for improvement.

Another essential step in this phase is to identify and document the security and privacy requirements for the Avatar system. This includes identifying the type of sensitive data, potential threats, and relevant laws and regulations. Potential legal barriers to the development and operation of the Avatar system should also be identified and reviewed, which include laws related to the provision of

banking services, data protection, and other relevant regulations. At this stage, the needs and expectations of users should be identified and analyzed to ensure their acceptance of the Avatar system. It is important to examine the factors affecting the acceptance of technology by users and design the system in a way that meets their needs.

Therefore, according to the experts' opinions, a SWOT analysis can be conducted to draw a technology roadmap in the Iranian banking industry with the aim of identifying internal and external factors affecting the implementation of avatar technology. SWOT is a powerful tool for identifying internal strengths and weaknesses and external opportunities and threats.

Investigating and identifying internal and external opportunities and threats will greatly contribute to analyzing the gap of avatar technology in the Iranian banking industry. Based on interviews with research experts and library studies, the gap in this technology in the Iranian banking industry was analyzed. The purpose of this analysis is to identify the gaps between the current state of Iranian banking and the desired state (full use of avatar technology). Accordingly, the inadequacy of the technical infrastructure in Iranian banking for implementing avatar technology, the absence of specific laws and regulations for the use of avatar technology in Iranian banking, the lack of familiarity and trust of many customers with avatar technology, and the lack of expertise required to develop and implement avatar technology in Iranian banking can be considered the main gaps in the use of this technology in the Iranian banking industry.

Considering these gaps, investing in the development of technical infrastructure, formulating laws and regulations, holding educational and culture-building programs to familiarize customers with avatar technology, and attracting experts in the field of avatar technology and training existing personnel can play an effective role in filling the existing gaps.

Additionally, according to the research experts, the level of advancement of avatar-related technologies (such as artificial intelligence, natural language processing, etc.), the level of use of avatar technology in other industries and countries worldwide, the existence of the necessary technical infrastructure for implementing avatar technology in Iran, the existence of specific laws and regulations for the use of avatar technology in Iran, and the level of familiarity and acceptance of avatar technology by customers in Iran are considered criteria for the maturity of avatars in the Iranian banking industry. Accordingly, the maturity of avatar technology in the Iranian banking industry is not in a favorable state.

A noteworthy point at this stage is the identification and documentation of all requirements. Considering the above and analyzing the issues raised, decisions can be made regarding the channels used for avatars, the capabilities implemented in them, and how the services provided are delivered. It is advisable to focus on the basic needs of customers and the simple capabilities of avatars at this stage. Over time and with the improvement of infrastructure, more complex capabilities can be added to avatars. According to experts, the suggested duration for this stage is 6 to 8 weeks.

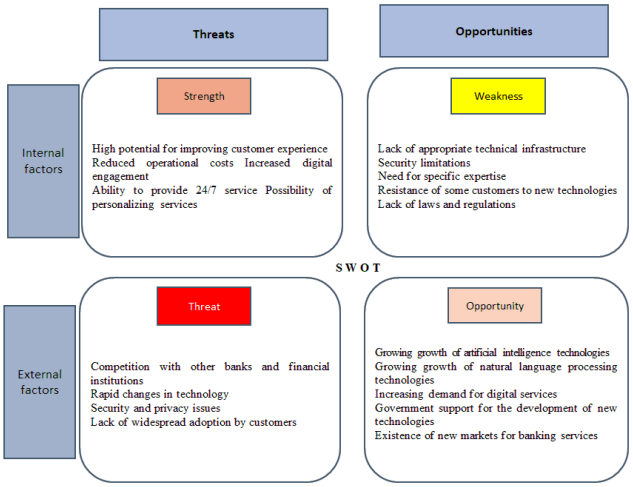

Fig. 3 SWOT Avatar in the Iranian Banking Industry (Source: Researcher's findings)

4-2- Systems Development

This stage will be carried out according to the analysis and identification conducted in the previous stage and involves transforming the initial designs and identified requirements into an operational system, establishing the technical foundations of the avatar. In this stage, the architecture of the Avatar Bank system is designed, which means determining the overall structure of the system, its components, and how the system components interact with each other. In simpler terms, this stage is like designing a building plan, where all details are specified before construction begins. The system architecture determines the overall project path, and by separating the system into smaller components and defining the relationships between them, the complexity of the project is reduced and the possibility of future system development and changes is provided. By specifying the roles in carrying out the project, the members of the development team can effectively collaborate, facilitating cooperation.

The components of the avatar system vary depending on the capabilities of the avatars, but typically include a conversation engine for natural language processing, response generation, conversation management, a database for storing user information, products, services, conversations, a user interface for user interaction with the avatar, channels through which the avatar communicates with users (such as Internet banking, mobile banking, branches), an authentication system, and a bank payment system for performing transactions. In this stage, the

relationships between the components and the method of communication are determined, communication protocols are established, and architectural diagrams are designed to display the relationships between the components.

Selecting appropriate programming languages, frameworks, databases, and development tools, selecting a cloud or local platform to host the system, designing a database structure to store the information required by the system, data normalization to prevent redundancy and improve efficiency, and designing security systems to protect user data and prevent cyber-attacks are other issues that should be addressed in the system architecture.

Based on the project needs, the skills of the development team, and the existing infrastructure, the appropriate programming language and framework are selected. This choice has a direct impact on the performance, maintainability, development speed, and costs of the project. Depending on each portal used (web applications, mobile applications, or back-end systems), different languages and frameworks will be more suitable for use. Languages and frameworks that produce clean and readable code make it easier to maintain and develop the avatar in the future. For example, in web application development, Python with Django is suitable for fast and scalable back-end development, JavaScript with React is suitable for building interactive and dynamic user interfaces, and Node.js is suitable for building server-side and real-time applications. For mobile application development, Swift can be used for developing iOS applications, and Kotlin for developing Android applications. React Native is also suitable for developing iOS and Android applications simultaneously.

According to research experts, Python is suitable for avatar design due to its ability to support the required technologies, such as artificial intelligence, its suitable speed, and high security. Additionally, using this programming language will reduce costs.

Although issues such as infrastructure limitations, changes in identified requirements, and system complexity cause problems in designing the appropriate system architecture, with focus and accuracy in proper design, we can prevent problems in the later stages of development and reduce development costs.

A suitable architecture guarantees system performance, scalability, maintainability, and security. Given the infrastructure limitations in Iranian banks and the need to interact with existing bank systems, the architecture should be designed in such a way that it can easily communicate with core banking systems, customer relationship systems, and other bank systems. The architecture should ensure that the avatar's performance does not suffer if the number of users and data volume increases.

Another important point in system architecture is information security in the avatar. The architecture must protect sensitive user information from security threats.

Information security in the banking system is of great importance. In the implementation phase of the bank avatar, special attention should be paid to security by design, and the necessary security measures should be taken at all stages of system development and implementation. Using strong authentication methods to prevent unauthorized access to user information and encrypting sensitive user data in the database and when transferring information, along with using firewalls, intrusion detection systems, and other security tools to prevent hackers from penetrating the system and performing regular security updates to remove possible vulnerabilities, are some of the things that should be given special attention.

Another important step at this stage is choosing the right platform and natural language processing engine as a crucial step in the development of the bank avatar. In choosing a platform, factors such as the scale of the project, budget, complexity of the desired interactions, and the existing infrastructure in the bank should be considered. A suitable platform should be able to support multiple channels and have the ability to interact with users through different channels, be customizable and able to customize the appearance and behavior of the avatar to suit customer needs, be able to integrate with existing systems, have a high level of security to protect user information, and be scalable given the increasing number of users and the complexity of interactions. The avatar should be simple, intuitive, and attractive so that users can easily interact with it. Choosing the right colors, fonts, and graphic elements is important to create an attractive user interface; the visual design should be such that it displays well on different devices, while ensuring that people with special needs (such as people with disabilities) can also use the avatar.

Natural Language Processing (NLP) Models are essential components of the avatar, responsible for understanding and interpreting the natural language of users. There are various natural language models that can be used in the bank avatar. Natural language processing models include rule-based models, which operate on a set of predefined rules and patterns and are suitable for simple tasks such as recognizing keywords and specific phrases, machine learning models that learn patterns in natural language using training data—these models are suitable for more complex tasks such as emotion recognition, text summarization, and language translation—and deep learning models that use deep neural networks to process natural language. These models are capable of performing very complex tasks such as understanding the meaning of sentences and answering questions. Choosing the right model for a bank avatar depends on various factors such as the complexity of the tasks, the amount of training data available, and the available computing resources.

Another requirement that should be considered at this stage is the database. The database contains information about the bank's products and services, rules and regulations, frequently asked questions and their answers,

and any other information that the avatar needs to respond to users. The database structure should be designed to provide quick and easy access to information. Information in the database can be stored in structured (such as tables) or unstructured (such as free text) forms. To ensure that the information is up-to-date, a system should be created to manage and continuously update the database. Choosing the right database is very important, depending on the type of data, its volume, and how it is used. Experts have chosen PostgreSQL as a suitable option due to its ability to store and retrieve large amounts of data, speed and efficiency, scalability, security, and cost, and have emphasized its low cost and expandability.

The Application Programming Interface (API) is another area that should be considered in this section. It will be used to access information in the bank database such as customer information, account balances, and to perform banking transactions such as money transfers, bill payments. APIs will also be used to collect user feedback and improve avatar performance, develop an admin panel, manage users, manage the knowledge database, update information, monitor avatar performance, and identify potential problems.

It is important to consider challenges such as infrastructure limitations and technical complexities at this stage, while data scarcity and the need to coordinate with existing systems are also important factors.

At this stage, the security and privacy requirements identified in the previous stage should be included in the system design. It is important to pay attention to the use of secure architectures, encryption protocols, and access control mechanisms. Legal solutions should be designed and implemented to overcome the obstacles identified in the previous stage, which could include changes in system design, obtaining the necessary licenses, or changes in the way services are provided. The system should be designed in a way that meets the needs and expectations of users and provides a desirable user experience. This includes designing an appropriate user interface, providing the necessary training, and creating user feedback mechanisms. According to the human-computer interaction approach, designing a simple, intuitive, and attractive user interface that is tailored to the needs and abilities of users should be the criterion for action at this stage. Attention should be paid to designing natural and smooth interactions between the user and the avatar in the design of conversations and animations.

According to research experts, the suggested time for this stage is 8 to 10 weeks. Additionally, attention to customer data security should be a priority, and various tests should be conducted during the development process to ensure the proper functioning of the system. Given the infrastructure limitations of banks, it is better to focus on the basic capabilities of the avatar first and gradually add more complex capabilities over time.

4-3- Implementation and Coding of Systems

According to experts, in the implementation and coding of systems stage, the designs created in the second stage will be transformed into a usable product, with programming codes written and various components of the system connected to each other.

The type of project, the team's skills, and the performance of the programming language are among the factors that influence the choice of these factors. Frameworks provide a predefined structure for the project, saving time and effort, and allowing us to benefit from the experiences of others.

Developing the user interface is another key factor at this stage. The user interface is the user's first interaction with the avatar and plays an important role in the user experience. A good user interface should have an attractive visual design that is consistent with the brand, compatible with a variety of devices and browsers, and usable by users with specific needs. To develop a user interface, it is essential to create initial designs using design tools, build user interface components using the selected language and framework, and connect the user interface components to business logic.

Another factor to consider at this stage is the implementation of the conversation engine based on the selected models. The conversation engine is responsible for understanding and answering user questions. Types of conversation engine models include rule-based models that respond based on a set of predefined rules and patterns, and machine learning models that use machine learning algorithms to learn from training data and produce natural responses. To develop a conversation engine, factors such as collecting a large dataset of questions and answers, preprocessing data to remove noise using natural language processing, selecting the appropriate model based on the type of data and project needs, and training and evaluating the model can be used.

Integration with existing systems and connecting the avatar to various bank systems, such as the central banking system, customer relationship system, etc., through user interfaces should also be considered because it provides access to various information and services.

At this stage, the design and implementation of the database to store user information, conversations, and system settings should also be addressed. This involves identifying the main entities in the system, defining the relationships between entities, and creating a diagram to display the database structure. Security and privacy requirements should also be considered in coding and implementing the system, with the use of secure coding methods, implementation of security mechanisms, and conducting security tests. It is necessary to ensure that the legal solutions designed in the previous stage are implemented in the system.

Coordination between teams and change management are among the challenges of carrying out this stage, while the

complexity of the system may also create problems in implementation.

According to the human-computer interaction approach, the system implementation should be carried out with due care based on the designs made. At this stage, the system should be implemented in a way that users can easily use it and meet their needs.

The suggested time for the third stage, according to the research experts, is 14 to 18 weeks. It is recommended that after the development of each section, testing should be carried out to ensure the correct functioning of that section, and an effective communication system should be established between the design, development, and testing teams.

4-4- Testing

This stage is one of the most sensitive and vital stages in the system development life cycle and ensures that the developed system works correctly, complies with the initial requirements, and can provide a desirable user experience for customers. In the banking industry, which interacts directly with customers, the quality of tests is very important. The start of this stage requires the completion of the previous stages.

Due to the complexity of human-computer interaction and the importance of user experience, it is recommended that testing be performed continuously and throughout the different stages.

This stage should use unit tests to check the correct functioning of each part separately, ensuring that each component processes the inputs and produces the correct outputs. It is also important to check the correct functioning of the various components of the avatar when working together, ensuring that the different components communicate correctly and share data. It should also be tested to ensure the performance and functional evaluation of the avatar under different loads, such as a large number of users simultaneously, and to ensure that the avatar can meet the needs of users in different situations. It should also be tested to assess the ease of use of the avatar by users, ensuring that the user interface is attractive, intuitive, and user-friendly, and to assess the security vulnerabilities of the avatar to ensure that sensitive user information is protected.

Other areas that require testing include evaluating the avatar's behavior under abnormal conditions, such as system errors and network outages, to ensure that the avatar responds correctly to errors. End-user evaluation of the avatar to confirm that their needs are met is also essential.

In this phase, to validate the roadmap and before full deployment, the avatar is piloted on a small scale, and the results are reviewed. This work reveals strengths and weaknesses and can play a key role in the full deployment of the avatar.

Since the user experience approach of human-computer interaction has also been addressed in the technology roadmap in this research, user-centered testing should also be considered. Testing with real users to collect feedback on user experience, using various methods such as interviews, observations, and questionnaires, as well as measuring indicators such as task completion time, error rate, user satisfaction, and avatar usage, and using tools to track user behavior in interacting with the avatar and identify strengths and weaknesses should be on the agenda.

Security and privacy challenges are of particular importance, and the avatar must be tested for security and privacy. These tests include penetration testing, vulnerability testing, and compliance testing with relevant laws and regulations.

The complexity of human-computer interaction, continuous changes in artificial intelligence, and weak technology infrastructure are factors that may disrupt the implementation of this stage. In this stage, the system is tested by real users to ensure their acceptance. A kind of simulation of the technology adoption model is proposed to determine the impact of different policies on behavior change [50].

According to research experts, the general goal of this stage is to identify and fix potential problems before deploying the system in a real environment. Conducting various tests such as unit testing to check the correct functioning of each part of the system (such as the conversation engine, user interface, database, etc.), integration testing to check how different parts of the system interact with each other, system testing to check the overall performance of the system and its compliance with the defined requirements, user-centered testing to evaluate the user experience and user satisfaction with the system, security testing to check system security vulnerabilities and protect user information, and performance testing to check system performance under different loads (such as a large number of simultaneous users) is essential at this stage. Also, in order to use the test results in the next stages, they must be documented. The suggested time for this phase is 6-8 weeks and includes the need to design detailed and comprehensive tests to evaluate all aspects of the interaction, the need to continuously update the tests with new developments in the field of artificial intelligence, the need to design tests that take into account the limitations of the technology infrastructure, and establish a strong relationship between the test team and the development team to ensure high quality.

4-5- Establishment (development)

This phase is the transition of a software system from the development environment to the production environment. In simple terms, this phase is where the avatar is transferred from the laboratory environment to the real environment of the bank and made available to customers. Successful deployment indicates that the project has achieved its goals and is ready to serve customers. If the

system is deployed correctly, it directly affects the initial user experience and reduces the risks of technical problems and service disruptions.

When deploying the system, attention should be paid to issues such as installing software, setting up the database, and configuring the network, implementing security measures to protect customer data and prevent cyber-attacks, providing the infrastructure needed to support the avatar, transferring information from the development environment to the production environment, and ensuring data compatibility with the new environment. This ensures that the avatar works properly in the production environment and meets customer requirements.

Considering the user experience approach of human-computer interaction, attention to such aspects as ensuring that the user experience is seamless and smooth at all stages, including the registration and login process, providing technical support and guidance for new users, and collecting user feedback after deployment for continuous improvement of the system are also essential at this stage.

Training employees on how to use and support the system and informing customers about new capabilities and encouraging them to use the avatar should also be considered.

In deploying the avatar, challenges such as infrastructure complexity, information security, and organizational changes should also be considered. Additionally, the necessary security measures should be taken to deploy the system in an operational environment, which includes secure configuration of servers, installation of firewalls, and other security measures. At this stage, the necessary permissions for operating the system should be obtained from the competent authorities.

The avatar should be deployed in a way that users can easily access and use it. The duration predicted for this stage by research experts is 3 to 5 weeks. Monitoring the performance of the avatar in the early days and resolving any potential issues, preparing a detailed deployment plan (including timing, responsibilities, and resources required), conducting comprehensive pre-deployment tests to ensure proper system performance, and working closely with development, network, security, and support teams are some of the things that should be considered.

4-6- Operation and Maintenance of Systems

At this stage, the system is fully available to users and is used continuously. The main goal at this stage is to ensure the correct and stable operation of the avatar, resolve potential issues, and continuously improve it.

After the avatar is deployed, its performance should be monitored. Continuous monitoring of key performance indicators (KPIs) such as response time, error rate, and capacity is of particular importance. Identifying technical problems and resolving these problems proactively should be considered. Performance indicators such as customer engagement rate, reduction in branch visits, avatar response accuracy, and the impact on customer satisfaction are considered to be the most important key indicators of avatar performance.

At this stage, in addition to training users to use the avatar optimally, support should be provided to users in case of any problems or questions.

Another factor emphasized at this stage is to review the avatar's performance in order to make the necessary changes and modifications to improve it, so that new features can be added if needed by users and to accommodate possible changes in the banking industry.

Given the importance of data security in the banking industry, protecting avatar data against security threats is crucial, and security updates should be made regularly. Periodic data backups can also be useful for recovering data in case of serious problems.

Considering the conditions and characteristics of the Iranian banking industry, according to the research experts, the changing needs of Iranian bank customers and the need to adapt the avatar to these needs, as well as changes in technology due to the rapid growth of technology and the lack of appropriate technology infrastructure in Iranian banks, are among the most important challenges and problems of this stage. These challenges, along with the problems in the complex interactions between users and the avatar, have made this stage difficult. The avatar must be continuously monitored in terms of security and privacy, and corrective measures must be taken if necessary. It must also be continuously monitored for compliance with relevant laws and regulations, and necessary changes must be made as required.

Considering the user experience approach of human-computer interaction, it should be noted that collecting user feedback from using avatars and using this feedback to improve the user interface and performance of the avatar is crucial. Personalized support should also be provided to users based on their specific needs.

4-7- Proposed Technology Roadmap:

The six steps for developing the avatar technology roadmap in the banking industry were determined through the six-stage waterfall model of the system development life cycle, in alignment with expert insights and the user experience principles of human-computer interaction. Figure 3 illustrates the practical implementation timeline for each stage, while the main required actions, associated challenges, and user experience considerations for each step are summarized within the discussion provided in this study.

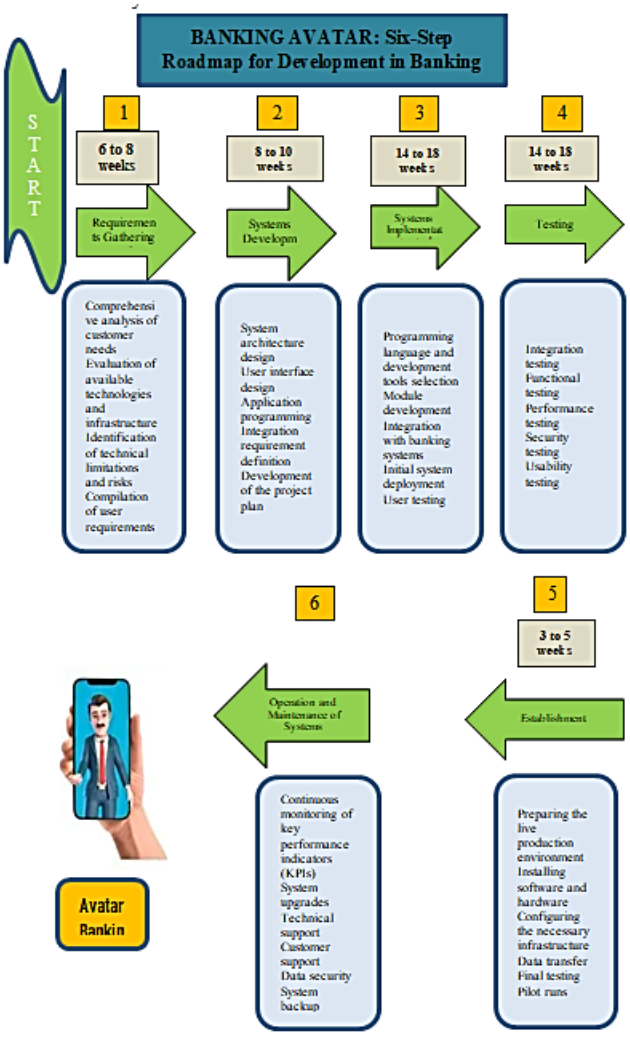

Fig. 4 Proposed roadmap for avatar technology (Source: Researcher's findings)

The implementation and use of avatars in the Iranian banking industry require planning for short-term, medium-term, and long-term strategies to benefit from this technology, according to the proposed roadmap.

Short-term strategies are specific and implementable actions for periods of 3 to 6 months. These include launching the initial version of the avatar and evaluating its performance, implementing the MVP (minimum viable product) version with limited features for testing in a real-world environment, testing user interactions with the avatar, receiving feedback, and optimizing technical and security infrastructures. Key performance indicators (such as customer satisfaction) are needed to measure progress in short-term periods. For this purpose, implementing a pilot version of the avatar technology in a limited range of banking services to evaluate its effectiveness and receive customer feedback should be considered. Developing and implementing a pilot version of the avatar (for example, to guide customers on the website or application), selecting a small group of customers to participate in the pilot test, and collecting quantitative and qualitative data on the customer experience (through surveys, interviews, and recording customer activities) are essential. Finally, analyzing the data and providing a preliminary report on the test results to identify the strengths and weaknesses of the pilot based on customer feedback within a 3- to 6-month period should be carried out.

Medium-term strategies are specific and measurable goals for periods of 6 to 12 months. These strategies are directly derived from long-term goals. Strategies such as improving and developing the banking avatar, increasing the capabilities of the avatar (adding advanced natural language processing, recognizing customer emotions, and intelligent responses), expanding platforms (providing avatar services in mobile applications of banks and banking kiosks), and evaluating the impact of the avatar on the bank's performance (reducing in-person visits, improving the customer experience, increasing productivity) are of interest. Planning medium-term strategies with the aim of improving and developing the pilot version of the avatar based on customer feedback and increasing its capabilities to improve the bank's performance (e.g., reducing costs, increasing customer satisfaction, increasing efficiency). Improving the design and user interface of the avatar based on customer feedback and adding new capabilities to the avatar (e.g., the ability to answer complex questions, perform simple financial transactions) are essential.

Implementing the avatar in other communication channels (e.g., including the avatar in bank branches), along with measuring the impact of the avatar on the bank's performance (e.g., reducing customer waiting time, increasing customer satisfaction, reducing customer service costs), are among the programs that can be implemented in the medium-term strategy. These will be implemented by providing a full report on the results of the avatar improvement and development within a period of 6 to 12 months.

Lon-term strategies are considered for 1 to 3 years. The long-term strategy includes major goals such as integrating and developing advanced capabilities, adding augmented reality and virtual reality technologies for remote banking consultations, integrating with other banking systems and smart trading robots, and complying with international standards to enter advanced digital banking. Other pillars of long-term strategies include vision and scope. According to experts, the vision and scope of using avatars in the Iranian banking industry by 2030 is to use smart avatars to provide a personalized, fast, and user-friendly experience for Iranian bank customers. This technology will lead to a 30% reduction in in-person visits, a 50% increase in customer satisfaction, and a 40% optimization of banks' operating costs.

In accordance with the planning for long-term strategies and achieving the vision of using avatar technology in the Iranian banking industry, action should be taken to add augmented reality technology and enter digital banking to create innovative experiences in digital banking and increase customer satisfaction by 2030. According to the planning, in a 3- to 5-year period, research and development should be carried out in the field of integrating augmented reality technology with avatars, developing and implementing new features using augmented reality technology (e.g., 3D display of customer accounts, guiding customers in bank branches), developing and implementing digital banking solutions using avatars (e.g., performing complex financial transactions with the help of avatars), measuring the impact of avatar technology on customer satisfaction and bank performance by 2030, and presenting a final report on the results of implementing the long-term strategy. Attention should be paid to the vision of drawing customer satisfaction through providing innovative and personalized experiences using avatar technology and augmented reality. Another point in implementing the planned plan is to pay attention to the challenges ahead of the avatar technology roadmap in the banking industry. Obstacles and challenges such as infrastructure and security restrictions due to weak internet and data security in some Iranian banks can be overcome by using secure cloud servers [62] and advanced encryption technologies. The challenge of user acceptance and culture building is also of concern because some customers, especially the elderly, may not trust avatars. For this purpose, educational and digital marketing programs will be useful to familiarize customers with this technology. Legal and regulatory challenges and the lack of specific rules in the field of financial interactions with banking avatars can be overcome by creating banking laws and standards.

5- Discussion

The proposed avatar development roadmap, grounded in SDLC and enriched with HCI principles, outlines a stage-based framework for conceptualizing, designing, deploying, and maintaining avatar services in Iranian banking. Each stage—requirements analysis, design, implementation, evaluation, and maintenance—is linked to specific deliverables and decision gates that combine technical rigor with user-centric evidence [14].

Compared to earlier avatar deployment studies in financial services [44], our results demonstrate greater alignment between interaction design and organizational integration. Prior works have largely emphasized interface appeal and novelty; by contrast, our roadmap formalizes enterprise-level governance, regulatory compliance checkpoints, and integration of user evidence at each gate.

Our findings substantiate the theoretical claim that integrating HCI within SDLC enhances both usability and operational outcomes. The dual-framework approach ensures that human factors are embedded in technical project controls, reducing the gap between conceptual prototypes and production-ready systems.

For practitioners, the roadmap offers actionable guidance on stage sequencing, role allocation, and artifact creation. Banks can adopt this framework to improve avatar adoption rates, streamline change management, and enhance customer satisfaction metrics. By embedding evaluation protocols into each stage, project teams can proactively identify and resolve user-experience issues before full-scale rollout [45].

This study, while comprehensive in its conceptual design, is limited by its reliance on secondary literature and expert validation. Empirical measurement of roadmap-guided deployments in live banking contexts remains a future task. Contextual constraints—such as evolving Iranian banking regulations and digital infrastructure maturity—also delimit the generalizability of our findings.

6- Conclusions

This study established a structured and context-aware roadmap for avatar technology implementation in the Iranian banking sector, integrating proven principles of the System Development Life Cycle (SDLC) and Human-Computer Interaction (HCI). The research process involved comprehensive literature review, expert consultations, and in-depth analysis of local banking needs and constraints. Key development stages—including requirements gathering, design, implementation, testing, deployment, and maintenance—were thoroughly defined, and actionable guidelines for each phase were presented with a focus on user experience and operational feasibility. Collaboration with banking and IT professionals ensured practical alignment and relevance throughout the framework.

The main research innovations and unique contributions of this paper are:

1. Development of an integrated SDLC–HCI framework for avatars: Introducing a systematic approach that aligns the technical progress of banking avatars with rigorous usability standards and user-centric practices, tailored specifically for Iranian banks.
2. Precise definition of each stage and its deliverables: Providing clear operational guidelines, decision gates, and performance measures for every roadmap stage to facilitate effective implementation and project governance.
3. Addressing Iran-specific banking challenges: Adapting all stages of the roadmap to domestic banking regulations, infrastructural realities, and

cultural requirements, ensuring readiness for real-world deployment.
4. Strategic vision for phased development: Articulating distinct short-term, medium-term, and long-term pathways for the scalable and sustainable evolution of avatar-based services in Iranian banks.
5. Direct practical applicability: Offering the banking sector a tangible blueprint to accelerate digital transformation, improve customer engagement, and enhance overall service delivery without reliance on artificial intelligence technologies.

By coupling solid methodological foundations with a robust, locally tailored strategy, this research bridges academic rigor and industry needs—enabling Iranian banks to confidently pursue avatar adoption while addressing the unique operational and cultural challenges of their environment [51,52].

7- 7- Directions for Future Research and Practical Development

Looking ahead, the continued evolution and successful integration of avatar technology in Iranian banking depend on targeted research and strategic development efforts. Although the current study delivers a comprehensive roadmap and practical framework, further exploration is necessary to extend its impact, address real-world complexities, and unlock new opportunities for innovation in banking services. The following areas are recommended for future study and action:

1. Empirical implementation and evaluation: Pilot deployments of the proposed roadmap in selected banks, with systematic measurement of customer experience, operational results, and user acceptance, will validate and refine the framework under real conditions.
2. Enhancement of service integration: Investigating methods to connect avatar solutions with diverse banking systems and customer service platforms, supporting more seamless and efficient operational workflows.
3. User feedback and iterative improvement: Establishing routines for collecting and acting upon end-user feedback to ensure the avatar's ongoing usability, reliability, and alignment with evolving banking needs and customer expectations.
4. Cultural and trust-building initiatives: Conducting targeted studies on the social and cultural factors that influence customer trust and acceptance of avatars, and developing evidence-based strategies for digital literacy and technology adoption.
5. Sector-wide adaptation and expansion: Assessing opportunities to apply the roadmap to related industries—such as insurance or government services—to demonstrate its value beyond the banking sector and foster broader digital transformation.

These future research directions will require coordinated collaboration among technology experts, banking practitioners, and regulatory bodies. Their successful pursuit will further strengthen the foundations for effective, user-centered digital banking services in Iran—without reliance on artificial intelligence technologies.

Appendix

There are no appendices included in this article.

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