Bits, Bytes, and Bars: Towards a Digital Twin of the US Criminal Justice System

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Digital twins have been successfully used in various sectors to monitor performance, understand systemic problems, and evaluate solutions. However, their application in social contexts remains an emerging area of research. Gallup survey in 2023 reported that only 20% of Americans say they have a "great deal" of confidence in the US Criminal Justice system, and it makes exploring the potential usage of digital twins for advancing criminal justice an interesting social issue. Through a multidisciplinary focus group, this exploratory study investigated the challenges, potential benefits, and use cases for implementing digital twins in the US criminal justice system. The identified challenges are ethical issues, resistance to change, competing narratives, limitations of applying industrial perspectives to social issues, and power dynamics. Building digital twins in criminal justice can offer significant benefits, such as promoting equity and fairness, enhancing efficiency, resource optimization, and improving public safety. The study recognized the role of human-computer interaction in addressing these challenges and adapting digital twins for use in complex social systems. It recommends that policymakers consider a pilot project to test digital twins' benefits.

CCS Concepts: • **Social and professional topics** → **Government technology policy**; • **Human-centered computing** → *Interactive systems and tools.*

Additional Key Words and Phrases: Digital Twin, Criminal Justice, Transparency, Social Justice

1 INTRODUCTION

There is growing interest in digital twins as innovative solutions for real-world challenges. Digital twins create virtual representations of natural, engineered, or social systems that aim to accurately mimic the behavior of their real-world counterparts [15, 71]. Digital twin has been widely applied to aerospace[80], manufacturing[55], supply chain management[48], city planning[93], and medical care [49] to create insights and optimize the processes by simulating scenarios based on real world data without influencing the real world environment[14, 21, 38, 104]. Interest in digital twins has expand beyond the physical systems, and it has applied to simulate human decision making by creating cognitive digital twins. [97, 121]. Creating a virtual representation of society grounded in real-world data could enable novel approaches to analysis, decision-making, and policy development [38].

The concept of digital twins has progressed from theoretical to practical applications in several domains in recent years[1], however there has been limited research exploring the development of digital twins for modeling entire societies, and searching the query of "digital twin of society" in Google Scholar has returned only 16 results on March 29th 2024, Notably, the field of urban planning has seen the emergence of social digital twins," which, has less focus on behavioral factors of society and mostly focus on technological infrastructure for data collection of citizens such as drivers [13, 84, 112, 122].

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Chircu et al.[12] proposed that a digital twin of society can assist public agencies and policymakers in interpreting trends and challenges to ensure prosperity and societal development. They presented a proof of concept for utilizing public data in creating digital twin of unemployment, and highlighted how utilizing open government data in the German employment agency has the potential to guide their future strategy in helping the German society manage job markets and plan for re-skilling and retraining specially in regard to technological change in economy.

Ulmenstein et al. [110] suggested using public health surveillance data to develop a digital twin in order to simulate the spread of infectious diseases.

Wang et al. [114] have integrated serious games with digital twins to explore social interaction for post-COVID urban planning. They used the Minecraft game as a sandbox for studying interaction with urban environments, leveraging its multiplayer nature [114].

The development of digital twins of society is an emerging space with several challenges such as public trust, privacy, transparency, informed consent, or bias[38]. However, the degree of these challenges depends on the type of solution that the digital twin is applied for and the nature of data that informs its function. Predicting human behavior on the scale of an entire society can undermine the autonomy and freedom of people[38].

This gap is also recognized in the criminal justice domain, where the potential of digital twins remains largely unexplored despite the pressing need for innovative solutions to address systemic issues. At the time of this research, the authors did not find literature that discussed the implementation of digital twin solutions in the criminal justice system. The implementation of digital twin solutions in the criminal justice section could have the potential to enable unprecedented insights regarding the safety of society.

The state of criminal justice system mostly reported statistically in the form of numbers in government dashboards and newspapers[87]. However judges consider the story not just the numbers, and these numbers can become an end in criminal justice that is separated from the context of what happened to people [22, 28], and these" numbers cannot speak for themselves" [44]. Scholars noted that the use of quantitative metrics can remove the specific experiences of the people involved, those being evaluated and those doing the evaluation[60, 83]In other words, the quantification of criminal justice erases the detailed narratives and trajectories of individuals' lives [83].

Understanding the context of these numbers matters and can advance criminal justice to the next level [87]. Narratives and stories about crime and criminal justice shape public opinion about the criminal justice system [30]. However, the factual stories are rarely visible or comprehensible in publicly available dashboards[75].

The current criminal justice information systems has focused on workflow management and did not consider the need to capture a representation of the context. [87]. Stories, as qualitative information, have the power to change the outcome of cases and influence and impact reforms in criminal justice based on which stories are embraced or dismissed by decision-makers [65]. There are many examples where laws were created as a result of a story and cases are actually decided based on the stories[16, 29, 79, 115]. However, this is visible only to a subset of practitioners and only decontextualized numbers propagate through the system and inform the society. According to recent Gallup poll, trust in the criminal justice system has reached a record low of 20% [85]. Developing a system for creating a narrative-driven digital twin of criminal justice might be a solution for increasing transparency and restoring trust in the criminal justice system.

This exploratory study seeks to investigate whether a digital twin can be a viable solution for the criminal justice system. Drawing inspiration from successful implementations in other sectors, this research aims to explore the potential application of digital twins in the context of criminal justice. While digital twins have been successfully applied in various industrial and urban planning contexts as discussed in prior lines, their potential application to complex social

systems like criminal justice remains largely unexplored, and is only limited to the creation of the digital twin of crime scenes for forensic purposes[23, 45]. Current literature lacks a comprehensive understanding of the challenges, benefits, and approaches for implementing digital twins in criminal justice. This gap is significant because unlike physical systems, the criminal justice system involves complex human interactions, and ethical considerations that may not be easily captured by industrial digital twin approaches.

To address this research gap, we pose the following research questions:

RQ1: What are the challenges for building digital twin of criminal justice system?

RQ2: What are benefits of building digital twin in criminal justice system?

RQ3: What are approaches for building digital twin in criminal justice?

This study explore these research questions through a focus group study. We suggest that this research is significant as it could pave the way for innovative approaches to enhance transparency, fairness, and efficiency in the US criminal justice system.

Foucault's Panopticon[32] , and Giddens' structuration theory [33] were used to guide the sociological analysis of the study. This approach extends the potential impact of this work, beyond criminal justice. It presents practical and theoretical contributions to the emerging area of research toward developing digital twin of the society. The challenges, benefits, and approaches identified in this context may potentially inform future work on applying digital twins to other complex social systems.

While there are limitations in generalizing the findings of the study, this exploratory study represents a first step towards understanding how digital twin technology could be leveraged to address challenges in the criminal justice system, and potentially restore the trust in this important institution.

Lastly, this study by putting the focus on the story, and narratives in criminal justice contributes to underexplored area of narrative based interfaces by exploring potential usecases in government dashboards. the study was intentionally delimited to use of narrative in criminal justice for building digital twin for three key reasons: (1) the disconnect between statistical dashboards and narrative-based judicial decision-making, (2) the pressing need to improve public trust in the criminal justice system through more accessible information presentation, and (3) recent advances in natural language processing that make narrative-based interfaces increasingly feasible.

2 BACKGROUND

This work builds on several strands of research, most notably research on information systems in criminal justice, socio-technical systems, and human-information interaction to explore solutions for giving meaning to data of sentencing in criminal justice.

2.1 Information Systems In Criminal Justice

Criminal justice can be considered as a group of organizations that provide safety to citizens, and society [11, 20]. The different components of this system, such as the law enforcement agencies, the public prosecutors, and the judicial courts, cooperate to uphold the law [91]. The connections and disconnections in this chain of cooperation, made a case for applying concepts of supply chain management in criminal justice systems, specially for information sharing [20, 90]. The multiple components in the criminal justice supply chain have their own dedicated information systems, such as risk assessment tools, policing databases, criminological analysis platforms, and systems for prosecutorial case management and court records [24].

One notable example of strong collaboration is in the criminal justice system in Charlottesville/Albemarle, VA, which has emerged as a national leader in promoting evidence-based decision making. Local authorities, including police, jail, pre- and post-trial services, and courts, have collaborated to leverage data and analytics more effectively across legacy systems [82]. Their efforts highlighted the importance of data integration, advanced data visualization techniques, and robust data management practices in harnessing the potential of data to evaluate performance measures, promote transparency and accountability, and ultimately drive more informed policymaking and practices within criminal justice system.

El Bashir's study on the criminal justice system in Philadelphia, New York, and Chicago illustrates the opaqueness and complexity of data exchange in criminal justice information systems [25]. For example, their investigation argued that it is hard to examine how a felony case can proceed along dozens of different paths, making it difficult for data practitioners outside of an attorney's office to understand how these possibilities can map to data. El Bashir has highlighted the role of open data initiatives in advancing criminal justice for delivering accountability. [25].

The challenge of data accessibility is not unique to the United States criminal justice system. In the United Kingdom, Pope et al. [81] identified similar issues, such as poor data quality, significant data gaps, inadequate linking of relevant data across organizations, and difficulties for external researchers in accessing data. They noted that these challenges hinder the ability of data analysis insights to effectively inform and influence policy actions. To address these issues, Pope et al. [81] advocated for the adoption of data justice policies that promote open justice. Such policies would aim to improve data quality, bridge data gaps, facilitate better data linking across relevant organizations, and make data more accessible to external researchers.

In addition, user-centered design and co-design of information systems can play a crucial role in addressing issues within the criminal justice system. Nigatu et al. [72] emphasized the importance of involving key stakeholders, such as investigative journalists and public defenders, in the design process of document organization tools used in the criminal justice domain. By collaborating with these stakeholders, designers can create tools that better support their work in promoting transparency, accountability, and fairness.

2.2 Digital Twin as a Socio-Technical System

Since digital twins emerged from the manufacturing world, most theoretical understanding of them relies on engineering-driven physical simulations. As a result, there is a gap in the social understanding of digital twins, as mentioned by Barn [4]. Barn et al [5] remarked that as digital twins are increasingly used to model elements of human interaction with cyber-physical system components, they should be viewed as socio-technical systems that integrate both technological and human elements[5]. Parmar et al[78] studied the requirements for building of digital twins of organization and argued that digital twins are not only about technology and they are about people, skills, and careful attention to interaction within organization , and highlighted the need for training of people for new skills.

As digital twins have evolved, their application has expanded beyond industrial settings to encompass complex social systems. This expansion necessitates a clear distinction between traditional industrial digital twins and social digital twins. While both conventional industrial and social digital twins integrate human actors, technological elements, systems, and data sensors, social digital twins require significantly more attention to human dynamics such as emotions[19], cognitive processes[50], and social interactions [58] which are shaping human digital twins[58].

The necessity of developing socially-oriented digital twins has been studied in urban planning since this area shifts the understanding from traditional physicial systems to citizens and their activities in a city as a system [4].

Urban digital twins are socio-technical systems that integrate both the technology and the human elements. In designing urban digital twins, human factors like behavior, perception, and citizen science input are considered just as important as data from electronic sensors[84].

Yossef Ravid and Aharon-Gutman [2023] explored social urban digital twin of a city both as tool, and concept which incorporates data from institutional bodies such as municipalities, and civic data for generating insights to meet the analytical needs of decision making, however the narratives created based on these social data can be different from the physical realities, since these data is not captured with intention of capturing social complexities, and recommended thick data mapping which refers to collecting data not just about the current specific questions, but questions in a broader unanticipated scenarios. They also warned about the imbalanced power dynamics in the creation of social digital twins that arise from competing narratives: one is driven by corporate interests that frame smart urbanism through crisis and technological redemption versus a counter-narrative that emphasizes civic engagement and social needs for building the socio-technical imaginary of smart cities [54, 119].

The rising ethical consideration around privacy, bias, and influence of digital twins on evolution of societies, has raised concern to study of human-digital twin interactions [71], and the National Academies [2023] emphasizes the importance of implementation science for digital twins, user-centered design, and adaptations of human behavior for effective human-digital twin teaming[71].

Adopting a socio-technical system perspective encourages considering all pertinent social elements, including legal frameworks, user needs, and ethics, when designing a technological solution, which is a digital twin of society in this case [106].

In the context of this paper, we define a social digital twin as a virtual representation of a complex social system that not only incorporates physical elements but also including the modeling of human behaviors, institutional processes, and the web of social interactions, often utilizing multiple human digital twin.

2.3 Narrative Based Interfaces and Generative AI

Narrative-based interfaces represent an innovative approach to human-information interaction that harnesses the power of storytelling. The narrative-based interface relies on the studies that demonstrated the effectiveness of storytelling in sharing and consuming information [70, 118]. Stories and narratives have been crafted and shared throughout human history. [35, 36]. Narratives make it easier for people to grasp dense material more than non-story-like information[64], and utilizing them in the user interface makes an analysis of spatiotemporal information easier [70]. Furthermore, narrative based interfaces has potential to bring empathy toward the presented information, as the brain responds to storytelling by producing oxytocin, and evoking empathy among the readers[107]. Empathy building has potential to improve understanding of parties involved in the criminal justice system including staff, court practitioners, and judges, specially in reducing discrimination for reentery of offenders [68].

Despite these promising potentials, the limitations of natural language processing research were a barrier to the adaptation of narrative-based interfaces [35]. Generative AI and large language models like ChatGPT have recently enabled cohesive narrative generation. Gurselli et al.'s study [39] demonstrated that ChatGPT's capacity to produce stories, but also to visualize them, unlocking new possibilities. Researchers have explored using LLMs to produce written narrative texts from data such as charts [102].

2.4 Sociological Perspectives on Technology, and Criminal Justice

While there is a variety of sociological theories that can explain interactions in large social context in HCI literature [89, 111], and criminal justice publications to address criminology [43], our aim here is not to review all the theories discussed in these disciplines. Rather, we focus on presenting essential theoretical lenses for the analysis of our study.

Michel Foucault's concept of panopticism [32] provides a framework for analyzing how surveillance technologies, potentially including digital twins, might alter power dynamics within a system. Foucault's work explores how surveillance can impact society. This theory illustrates how prisoners, constantly visible from a central watchtower, may change their behavior; even when they do not know whether they are being watched or not, they self-discipline due to the mere possibility of surveillance [56]. While this theory was developed before the emergence of social networks, it offers a paradigm for understanding how the perception of data access can internalize new societal norms and ways of thinking within a power structure, and how it gives power to authorities[66].

Structuration theory is the other foundational theory that has guided this research. Giddens [1984] proposed that the actions of people are shaped by three modalities of the structural system: interpretive schemes, facilities, and norms. The duality of structure is the core aspect of the structural system. It argues that social structures, such as institutions, both shape human actions and are shaped by those actions in a recursive manner. These modalities are mediating concepts that describe how larger social structures are connected and reproduced through individual interactions.

As outlined by Orlikowski [2000] in describing the technology-in-practice for organizations, we see this theory from the socio-technical HCI perspective: people interact with facilities which are software, hardware, and data contents, and these systems are being reconstituted through their continuous situated actions [41]. Users' understanding of the systems and their perceptions are the interpretive schemes, and lastly, norms are conventions for cultural norms in the organization which can potentially be reproduced in the algorithmic systems [7]. This duality can be found when human agency and algorithmic infrastructures mutually shape each other, just as individuals and power structures mutually shape themselves.

Structuration theory illuminates how users can resist to change in algorithmic systems to preserve their perceived advantages, and how it potentially impact the change in the deployment of the systems. This aspect is not limited to resistance to change, but also can be seen in reproducing bias in electronic systems, or as Eubanks[2018] highlighted the potential risk of reinforcing unfairness in the automated algorithmic systems in punishing the poor population [7].

3 METHODS

This exploratory study adopts a qualitative, constructivist approach, which is well-suited for exploring complex socio-technical phenomena in HCI research [17, 94]. This methodology acknowledges the socially constructed nature of reality and the value of contextual insights in understanding emerging technologies like digital twins in criminal justice. Instead of focusing on statistical findings, the constructionist offer analytically transferable insights that contribute to the broader understanding[86], which in this case is the technology's potential impacts on human practices in sensitive domains.

To gather diverse perspectives on this complex topic, this study followed a semi-structured focus group methodology of multidisciplinary experts to collect data for analysis as outlined in[18] . The transcript of the focus group is then analyzed following the grounded theory method as explained in[74]. This approach includes two main steps: focus groups and analysis through grounded theory. The study protocol was reviewed and approved by the Institutional Review Board at the authors' institution.

A focus group was conducted to explore the concept and potential applications of a narrative-driven digital twin of society within the criminal justice system and its potential impact on criminal justice. Focus groups are useful when there is limited understanding of the subject matter, and researchers aim to explore an emerging topic [18]. The approach of Wiegand et al. [117] in gathering people from a technological intervention domain together with people from problem space was followed.

3.1 Participants

The participants was selected through purposive sampling. Purposive sampling is recommended in literature since focus group discussion relies on the ability and capacity of participants to present relevant information[69]. Specially, purposive sampling of experts is a constructive tool when researchers aim to investigate new research areas [26]. The list of all participants and their backgrounds are listed in Table 1.

While the participants brought 117 years of relevant combined experience to the focus group discussions, we acknowledge that our purposive sampling approach and limited sampel date may limit the representativeness of perspectives. However, given the limited literature on digital twins in social domains, and particularly criminal justice, this initial focused expert discussion aimed to establish foundational insights for future research in this emerging domain.

Table 1. Focus Group Participants Characteristics

ID	Expertise	Sector	Experience	Rational
P1	Criminal Justice	Justice System	32 Years	Criminal justice is the main problem of study
P2	Criminal Justice	Justice System	12 Years	Criminal justice is the main problem of study
P3	Criminal Justice	Academia	10 Years	Criminal justice is the main problem of study
P4	Law	Academia	24 Years	Criminal justice is interconnected with Law, and addressing legal implications of the DT in criminal justice
P5	Digital Twin	Industry	30 Years	Digital Twin is the technology that is intended to be used to address the problem
P6	AI	Industry	9 Years	AI is the technology that is intended to be used to address the problem

3.2 Procedures

The focus group was conducted virtually in May 2024 using the Zoom application. Although virtual sessions allowed experts from different locations to participate, this format may have limited spontaneous interactions compared to meeting in person[52]. The first researcher moderated the focus group, which lasted 105 minutes. During the first session lasted almost 75 minutes, participants were engaged in a semi-structured discussion aimed at exploring their perspectives on criminal justice and digital twin technologies. The focus group protocol had questions to allow the participants to identify challenges. The questions were grouped in two sets. The first set included three questions related to the criminal justice domain:

- How can the narrative of cases advance criminal justice?
- What challenges do you see in applying the concepts behind the digital twin in the criminal justice system?
- In what area you think the digital twin can be applied to criminal justice?

The second set included two questions related to advanced technologies:

- How do you construct digital twins?
- What are the technologies for building digital twins?

The second session started after a short break and lasted nearly 30 minutes. The experts participated in a brainwriting activity. Brainwriting is a popular method to collaboratively generate a large number of ideas [101] in a short time [109]. The brainwriting steps indicated in [109] were followed using the Whiteboard application of Zoom. Each participant was asked to write answers to this question: "What are potential scenarios for creating and using the digital twin in the criminal justice system?"

Participants wrote their answers on the whiteboard. After ten (10) minutes, participants engaged in a verbal discussion to complement the shared ideas. The session concluded with a discussing the favorite ideas of participants.

3.3 Data Analysis

The analysis of the focus group used the transcripts as the data source. The focus group session was recorded. In addition, two coauthors took notes. The first draft of the transcript was generated automatically from the Zoom application using speech to text technology. The first author reviewed the draft against the video recording and made corrections. The transcript was mostly correct and six(6) words were corrected.

The transcripts and brain writing notes were imported in MAXQDA 2022 application[95]. MAXQDA was recognized by the research community to be an efficient qualitative software to analyze the qualitative data rigorously and visualize results [96]. The analysis was guided by the strategies of Strauss [100] which further illustrated by [103].

The analysis included three step of open coding, axial coding, and selective coding, which discussed below:

In the first step, the first author read and inductively open-coded the transcript line by line using in-vivo codes. In-vivo codes are codes that employ the exact words or phrases used by participants, which helps to reduce researcher bias. This process followed the open coding manual of Khandkar et al. [53]. This process iterated three times.

Next, the codes were grouped by axial coding to define the relationships [100] which is guided by adaption of Zuidhof et al[123], and using MAXQDA Code relations browser [34]. This tool allowed the researchers to discover intersection of overlapping codes and relationship between the codes.

MAXQDA allows users to color the codes, and it can be useful for thematic analysis, as it assigns different colors to different topics[63]. The codes were grouped into the following colors. Red: Challenges, Green: Opportunities, Yellow: Narratives, Blue: General, and Purple: Scenarios.

The first author reviewed the transcripts for the second time and corrected inconsistencies in the second round of coding. All codes regardless of their frequency to reduce bias are reported, and 95% of transcript words were coded.

Finally, to conduct selective coding to define themes as guided by [103], the researcher asked himself: "Are they separate codes? Is one code a property or a phase in another?" [47]

After discussing the results with the research team, another round of coding was conducted by the first author, then themes were identified, discussed, and iteratively refined among the researchers to make sure they are coherent, and sufficiently distinct from each other to justify separation [2, 57, 108].

3.4 Credibility and Transferability

The research community suggests that traditional positivist measures of validity and reliability are inappropriate for constructivist research, as argued by scholars like Guba[1994], Stenbacka[2001], and Braun and Clarke[2013], who contend that quantitative reliability measures such as inter-coder reliability are inherently incompatible with qualitative methodologies [77, 105]. These methodological decisions were chosen align with established qualitative research in the HCI literature, though we acknowledge limitations of this study, and comprehensive discussion of limitations appears in Section 6.

First of all, the researchers employed in-vivo coding, as described in the above paragraph. This approach enhances the dependability of qualitative studies since the codes, the most fundamental element of analysis, are derived from the exact words in the data [3].

Secondly, the researchers employed an iterative approach in coding and analysis to enhance the transferability, conformability, and credibility of the study [51] by addressing potential bias through evaluation of the results with the research team.

Thirdly, by following the approach of Zuidhof et al.[2024] the detailed examples of quotation, and codes were provided to enhance the transferability of the research. In addition, the visualization of code distribution is presented in Figure 1.

4 RESULTS

A total of 92 codes were identified in the open coding process with 14 themes emerging in the analytical step. The themes and key findings, which are the outcomes of the analysis of the focus group transcripts, are presented in Table 2,4,3.

The coding process is demonstrated in figure 1 using the color coding. The red squares depicts the coding process of transcripts. Red squares indicate the challenges, the green squares indicate the opportunities of digital twins in the criminal system, the yellow squares discuss the narratives in criminal justice, purple squares belong to meaningful statements that describe scenarios of using digital twins in criminal justice, and blue squares discuss the keywords that do not belong to any of the aforementioned groups. White squares show uncoded areas, grey squares shows statements regarding understanding the concept of digital twin and black squares are facilitator statements, and transition statements in the transcripts.

In following paragraph, the results of thematic analysis for each research question are presented:

4.1 What are the challenges for building digital twin of criminal justice system?

The challenges of building digital twin in criminal justice are illustrated in Table 2 and discussed in the following paragraphs:

4.1.1 Data Concerns. Participants highlighted multiple interwoven challenges related to data that must be addressed when building a digital twin of the criminal justice system. A fundamental issue lies in the collection of data itself, as there are often gaps and inconsistencies in reporting, leading to underreported. As P1 outlined, the agencies only collect" static data that can measure" to keep the "numbers that matter to a specific person or for a specific program". For instance we may want to know not only how many people under your supervision are homeless, but how many of them are convicted of a particular offense and how many of them had served more than one incarceration and so we keep building on to what we want to know, And the systems just weren't designed for that because they were pretty

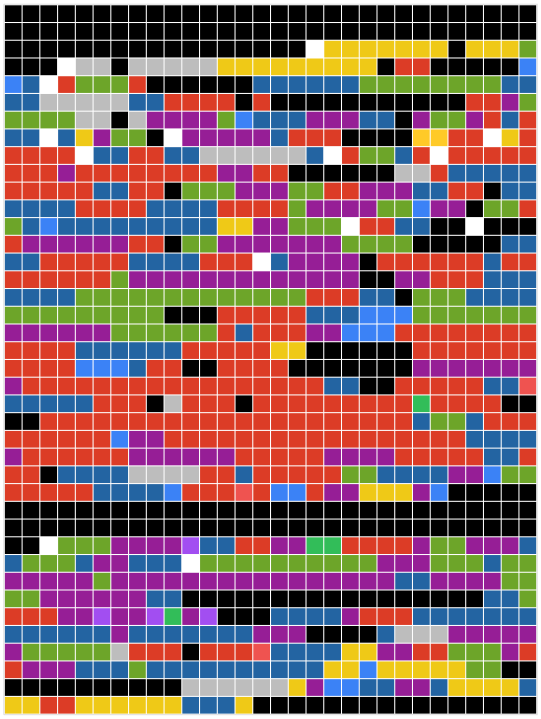

Fig. 1. Coding Portrait

one dimensional" Even when data is available, it may come from disparate sources that lack standardization, making integration and analysis difficult. As P5 noted, "the different governments and in states and things like that do not share a lot of information between them".

Furthermore, accessing real-time data streams can provide access to "real time observation of interventions"(P5).

4.1.2 Ethical Factors. Ethical considerations such as privacy, security, and civil liberties were raised as sensitive issues that need to be addressed when dealing with personal information and case details in a digital twin of criminal justice.

"You're dealing with really sensitive issues on one side public safety. And on the other side, people's privacy and potential liberties" (P2).

4.1.3 Resistance to Change. Participants noted that there could be resistance to change from various actors in the criminal justice system who may perceive the digital twin as a threat to established norms. In addition, conflicts of interest could contribute to resistance in the development of a digital twin in criminal justice.

"They may be worried about that and maybe rightly worried or wrongly worried there's a whole sort of fight about that" (P4).

And everybody, you know, there is an initial sort of. Loud group of folks who are gonna say oh this is terrible until it benefits" " I think you're starting to see a little bit of that is sort of the resistance to change and really anything to do with the system. Ever like the thing that people hate more than, you know, change is the status quo, right? (P6).

Themes	Codes	Example of quotes from participants
Data Concerns	Data Collection Not-Reported Data Available Data Lack of Standard Data Disparate Data Real Time Data Open Data Affordable Data Collection	"The system is being built based on the not reported data" "Data systems are clunk and cobbled together" "Collect everything under the sun... may not be realistic" "There's not a lot of open data on court stuff"
Ethical Issues	Privacy Security Liberties	"two big pieces will be privacy and security" "you have personal information for people and cases"
Resistance To Change	Actors Courthouse Attorneys Change Degree of discretion Sticky Norms	"Everybody hates change" "Narratives of a digital twin asses, evaluate, and threaten the discretion of some of these actors"
Competing Narratives	Conflict of Incentives Competing Interests Objectives Protagonist Void of Information	"there is no single narrative of a case" "Narratives are contested"
Industrial Approaches to Social Issues	People Society Manufacturing supply chain Variables Complexity Interactions Law on Paper Accuracy Unique Situation Product	"if you only have a hammer everything is going to look like a nail, so treating people with the same logic " "You wanna make a person digital twin, it is a lot of variables and biases" "It might be easy if you re trying to mimic a product manufacturing process because of standardization, but might be difficult because the law on the paper is not the same as how people act in the system, and there is a lot of variation"
Power Dynamics	Political Pressures Slow Government Cost	The political winds come and go", "it's gonna cost too much money " "Taking these legacy systems and creating agents to map out how these things could map a more modern system, That's getting better, faster, cheaper day by day. And so the excuses for government to not keep up with."

Table 2. Themes Regarding Challenges of Building Digital Twin of Criminal Justice

4.1.4 Competing Narrative. It was recognized that different stakeholders may have competing interests and objectives, leading to conflicting narratives about cases and the criminal justice system itself. A system that aims to represent the narrative of criminal justice needs to consider these competing narratives. Moreover, the participants pointed

out that there's no consensus on when a case officially begins, adding another layer of complexity to creating a comprehensive narrative. A system aiming to represent the narrative of criminal justice needs to account for these competing perspectives and the ambiguity in case timelines.

"Competing Narrative is a challenge" (P1).

"There is no single narrative of a case"(P4).

"Lawyers particularly in the plea bargaining process but even before and particularly in front of judges are often telling meeting narratives about a particular client situation, and telling stories about their client situation against competing stories"(P4).

4.1.5 Industrial Approaches to Social Issues(Hammering Human Problems). All Participants raised concerns about the limitations of applying industrial approaches, developed for manufacturing and supply chains, to complex social issues involving people, society, varied objectives, complexity, and unique situations. As P4 highlighted, "There is a lot of variation" in social interactions. "Predictable outcomes of digital twin in manufacturing" may not have the similar accuracy when they are being applied to "people problems", and applying algorithmic approach of industry is not easy to apply to people or as P6 remarked "A people business versus an algorithm. And how do you marry those or do you?"

Moreover, participants noted that social processes, such as the implementation of legislation, often differ from how laws are written or intended to function. The actual behavior of people within the system may not align precisely with the "law on paper" – the formal, written statutes.

4.1.6 Power Dynamics. significantly impact the implementation of new ideas. For example, the development of a digital twin of criminal justice could face political pressures, slow processes, and cost constraints. As P4 noted, there are "sort of political pressures as well as changes in personnel" that can affect such initiatives.

The current infrastructure of the criminal justice system largely relies on outdated "legacy systems." Transforming these into modern systems capable of collecting and processing data for a digital twin would require substantial investment. Political changes can make it difficult to justify these long-term costs. Another obstacle is securing data-sharing agreements between different actors in the system. As P1 noted, "Everyone has a different system, and getting agreement among the different stakeholders about what's important and how to measure it is extremely challenging.

4.2 RQ2: What are benefits of building digital twin in criminal justice system?

The participants discussed the benefits of creating a digital twin for the criminal justice system. Analysis of the transcripts identified five themes: Fairness, Efficiency, Insights, Accountability, and Public safety. The following sections elaborate the details of these themes, and Table 3 provide the overview of the analysis process.

4.2.1 Fairness. Participants emphasized the potential of digital twins in identifying and addressing disparities and biases within the criminal justice system. P3 stated, "Digital twins could be used to improve fairness by analyzing data and simulating various scenarios, offering valuable insights into the functioning of the criminal justice system." P6 further highlighted the capability of digital twins "to highlight some of the issues with the criminal justice system" and "to show where there is systemic bias to show where there's a problem".

4.2.2 Efficiency. Digital twins could significantly enhance the efficiency of the criminal justice system by providing a comprehensive view of its operations which can facilitate optimized resource allocation. Participants highlighted the potential of digital twins to identify bottlenecks and experiment with solutions. As P1 noted, these systems could offer "great ideas to make the system efficient, you just change this one process. So it could be a win-win." This sentiment

was echoed by P6, who envisioned a digital twin as "a map in front of you like a city and you could see you know what points of the system were slowing down you know this this judge is on vacation and we have a backlog here or we had you know 3 people fired from the parole office." A system like that would allow stakeholders in police departments and courts to visualize the state of criminal justice, pinpoint processing delays, and test potential solutions.

4.2.3 Insights. Participants recognized that digital twins could help fill gaps in currently available information about the criminal justice system. As P1 stated, "it provides information that we do not have today." For instance The digital twins can enable analysis of "experimental situations".

P2 noted that "any sort of assistance in anticipating the impact of interventions would be really useful," suggesting that digital twins could help predict the outcomes of different actions and decisions.

"The ability for a digital twin to highlight some of the issues can be helpful (P6).

4.2.4 Accountability. Digital twins can enhance accountability in the criminal justice system by providing transparent insights to public inquiries. This solution could address public curiosity about the criminal justice's operation. P1 highlighted this potential: "People are not quit asking questions, I mean, people are going to keep asking questions and eventually will have to be there. And if you have the road map to get , then is a win".

4.2.5 Public Safety. Participants suggested that digital twins could contribute to improved public safety by enabling better decision-making to control crimes. By providing insights and helping to test interventions, digital twins could potentially reduce harms associated with the criminal justice system. P4 highlighted this benefit, stating that digital twins could "save a lot of trouble on a lot of heart to folks" by helping criminal justice practitioners to prevent the occurrence of crimes in different contexts.

Themes	**Codes**	**Example of quotes from participants**
Fairness	Equity Bias Fairness	"to improve the fairness. " "to Show where there's there is systemic bias"
Efficiency	Efficiency	"you could see you know what points of the system were slowing down you know this judge is on vacation"
Public Safety	Reducing Harm Crime Prevention	" It saves a lot of trouble on a lot of heart to folks"
Accountability	Accountability Question	"Trying to be accountable to some system" " People are not quit asking questions"
Insight	Show Learn Address the void of information	"It provides information that we do not have today" "to highlight some of the issues with the criminal justice system"

Table 3. Potential Benefits of Anticipated Development Digital Twin of Criminal Justice

4.3 RQ3: What are approaches for building digital twin in criminal justice?

The participants discussed the approaches for creating a digital twin for the criminal justice system. Analysis of the transcripts identified four themes: Use cases, Human Computer Interaction, Development Strategies, and Generative AI. The following sections elaborate the details of these themes while table 3 summarizes the analysis process.4

4.3.1 Use cases. The focus group discussions identified several potential use cases for digital twins in the criminal justice system. Participants suggested using digital twins for decision-making, testing interventions, and creating experimental situations to predict outcomes and evaluate the performance of the criminal justice system. P2 suggested that potential scenario of developing the digital twin of criminal justice to to illustrate the journey of people in the criminal justice system system which can help decision makers to track "how quickly someone moves through the system".

Additionally, digital twins could be applied in specific contexts, such as police departments and city planning, to mimic reality and provide insights for decision-making. P6 illustrated the scenario of using digital twin in policing: " Right now shoplifting is a big deal, and a system can simulate the number of crime "If you could say you know, to the system. Look, judges, here's the amount of shoplifting cases that you're going to get in the next whatever, And allow them to, you know, plan accordingly or whatever and have it have a solid understanding of the other things that are going on in the criminal justice system and maybe allow them to rank order and triage what's going on, I think that that's a good day."

When connected to real-time data, digital twins can be used for live monitoring of the justice system. as P4 discussed, a potential scenario of using digital twin in identifying "red flags". The digital twins system can visualize "what's going on over over in X city?", and answer to the questions like "where are these sets of prosecutors suddenly charging this offense that folks over on the other side of the state aren't?

Conducting experiments and scenario based testing was a popular idea as discussed by P1,P2 ,P3 , P4, and P6. P1, and P2 suggested scenario of using digital twin in comparing or trying to evaluating of "sentencing outcome decisions" such as "arrest and charging". P2 illustrated these scenario that " [Users] create some sort of experiments within this digital twin to test these interventions, without doing harm to participants would be really really useful". It can be used also in case progress analysis by "You could tweak those small areas to see what happens as someone moves to the system. Being able to create a situation in which you could. You know, intervene and make it an experimental situation because those are so hard to do In real life."

P4 was also highlighted the potentials of digital twin in policy making, since it can be used to generate, ways of assessing prediction. " How system actors think things are gonna come out versus how well they are in predicting how well, how things are gonna come out versus actually how they come out".

P6 discussed that how a digital twin can be used to conduct creative experiments and aid in policing, he noted that " there's a tremendous amount of utility and being able to say, okay, hey, if we close down this street or got something happens with one of the bridges downtown, what happens to, you know, what happens to the city." A digital twin can be used to "perform weird experiments that could dramatically impact people's lives. I think that'd be super cool"

While it was anticipated that digital twins have data to simulate outcomes of different scenarios, we surprised that discussing digital twins as an innovative solution could work as a tool for bringing, ideating, and testing innovations itself or as P2 wrote in brain writing "a system for being able to create experiments to test innovations in the system".

"You will try to mimic the case. And what would be the results to predict the outcome and give it to the judges to make the decisions."

4.3.2 Human Computer Interaction. The coded statements highlighted factors which can be grouped as human-computer interaction in addressing the creation of digital twins of society. Participants recognized the importance of considering interactions between different people and groups within the criminal justice system, each with their own

Themes	Codes	Example of quotes from participants
Use Cases	Decision Making Testing out Interventions Experimenting experimental situation Criminal Justice System Performance Predict Testing accuracy Mimic the reality Police Department City planning Real Time Observation Shop Lifting	"The primary use I see from using the Digital Twin is tracking how quickly someone moves through the system" "Being able to create a situation in which you could. You know, intervene and make it an experimental situation because those are so hard to do. In real life." "You could tweak those small areas to see what happens as someone moves to the system." "You will try to mimic the case. And what would be the results to predict the outcome and give it to the judges to make the decisions." "Basically, you could say to a police department, or a large city, this is the percent of, Right now shoplifting is a big deal."
Human Computer Interaction	Interaction People Society Behavior Storytelling Persona Dynamic Visualization vignette studies	"It's a HCI kind of question" " What's the interaction effect between different people in the system with different interests?" "how people act" "what that persona need for decision making, and then build the model based" "HCI research or other forms of research about which stories work and which stories" " If there were at a dynamic, a dynamic visualization in real time of all the different things "
Development Strategy (How to)	Persona Objectives Dynamic Models Agent Based Modeling MVP Type of Data	"identifying a persona and what need for decision making and then build persona and what that persona need for decision" "start with a minimum viable product like, find some data"
Generative AI	Large Language Model Azure Generative AI Document Intelligence Hallucination Extract Summarize	"LLMs summarize for [Police] the 1st draft of a narrative" "The risk for hallucination is, is low because you're you're essentially telling the LLM to summarize "

Table 4. Themes Regarding Anticipated Approaches of Building Digital Twin of Criminal Justice

interests and positions. As P4 stated, "It's an HCI kind of question". If you generate a twin which generates a narrative. What's the interaction effect between different people in the system with different interests?"

Understanding how people act and their routine activities was deemed crucial, as P4 Stated: "We're talking about individuals or groups of individuals who are interacting with each other who are located in different places and are charged with different things and sort of where they are in the system where people like them are in the system."

Furthermore, understanding people's routine activities and the impact of exposing them to unfamiliar contexts is crucial when modeling the criminal justice system. As P6 noted, "You close the major artery, so you affected the routine activities of people and you basically took people who weren't normally exposed to this neighborhood and all of a sudden now they're all in this neighborhood to travel through".

The role of storytelling and narratives in shaping perceptions and decision-making within the criminal justice context was also highlighted, with P4 noting, "People process information through stories. And that leads to sometimes, depending upon the story, better processing, but it also may lead to worse processing."

As mentioned earlier development of persona was discussed . Dynamic visualization was also identified as a potential avenue for effectively presenting and interacting with the digital twin, as a participant envisioned: "If there were at a dynamic, a dynamic visualization in real time of all the different things we cared about happening."

4.3.3 How to: Development Strategies. Participants provided guidance on how to build digital twin of criminal justice. P6 suggested that the researchers should try to find "open data" and define the type of "available data" to create a minimum viable product. This minimum solution can be used to deliver insights and to be developed further as a starting point to build momentum for the digital twins approach. P5 suggested finding a specific need, building a persona, and developing digital twin of criminal justice for that personas. P4 remarked using vignette studies, agent based modelling and dynamic models for building digital twin of criminal justice.

4.3.4 Generative AI. P6 highlighted the role of generative AI, large language models, Azure, and document intelligence in building digital twin, and highlighted the risk of hallucination for extraction and summarization with LLMs is low. P5 pointed on using generative AI, and ChatGPT for building digital twins. In general LLMs can be employed to extract data from disparate data sources such as police reports, case management systems, and court data, and summarize the key facts in the anticipated digital twin systems.

4.4 Understanding the Digital Twin in the Social Contexts

Analysis of the focus group transcript revealed a need for further education about digital twins. Participants' discussions indicated confusion regarding what constitutes a digital twin and how it differs from other digital modeling approaches. One participant expressed their understanding as: "And from what I'm understanding, the concept of a digital twin is more or less working with a closed system. It's working with you have a set number of variables which is very easy or much easier to measure. In a manufacturing setting where you are working with products and you are able to track these things. Very easily through the system."

This comment suggests a perception of digital twins as primarily suited for closed systems with easily measurable variables, such as in manufacturing settings. It implies that applying digital twins to complex social domains like the criminal justice system would be challenging due to the difficulty in measuring and tracking variables in these contexts. This perspective underscores the need for further discussion on adapting digital twin concepts for use in social systems.

The thematic maps presented in Figures 2, 3, and 4 conceptualize the development of a digital twin for the criminal justice system. These figures show all challenges, benefits, and approaches for building a digital twin of the criminal justice system in one general picture. The thematic maps convey the significant codes that answer to the research questions. Some of the codes are placed between overlapping themes to illustrate the intersection between themes.

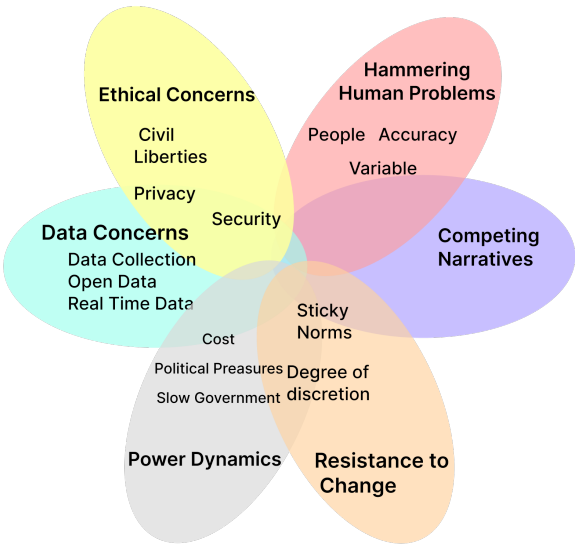

Fig. 2. Thematic Roadmap of Challenges

Fig. 3. Thematic conceptualization of benefits of Digital Twin for Criminal Justice

5 DISCUSSION

While this exploratory study has inherent limitations that are discussed in detail in Section 6, the analysis has revealed several significant themes regarding digital twins in criminal justice that requires detailed examination:

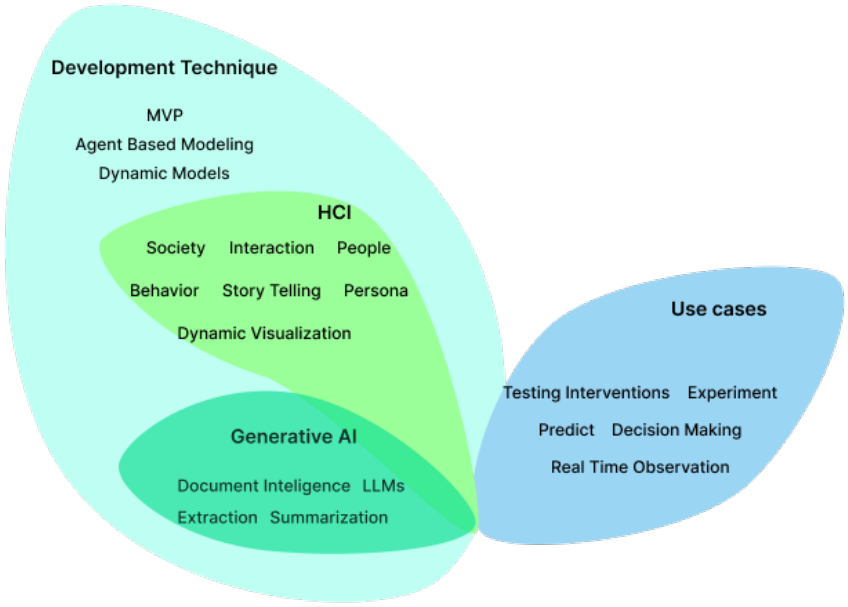

Fig. 4. Thematic conceptualization of Approaches for Building Digital Twin

Our findings extend traditional digital twin theoretical understanding by demonstrating how social systems require additional considerations beyond industrial applications, particularly in addressing human behavior and the competing narratives they have that shape the socio-technical dynamics.

From a practical perspective, our study presents several implications. These include challenges around data collection, resistance to change, political aspects, competing narratives of justice, ethical concerns, and difficulties in simulating human behavior. However conquering these challanges could be fruitful, since a digital twin of the criminal justice system could provide benefits such as promoting fairness, improving efficiency, generating insights, increasing accountability, and enhancing public safety.

An interesting unexpected finding was the potential role of digital twins as a tool for testing innovations in the criminal justice system. While digital twins are known as tools for monitoring and analysis by generating insights, participants highlighted how digital twins could serve as experimental environments for safely evaluating new policies, procedures, and interventions before implementation in the real world.

Moreover, the prominence of HCI considerations emerged unexpectedly, with participants emphasizing the need to carefully consider human elements in ways not typically highlighted in traditional digital twin applications, specially when it comes to narratives as As P4 who came from law stated, 'It's an HCI kind of question.'

Following lines, further contextualizes these themes and, when possible, reviews them against relevant literature. The anticipated development of digital twin in criminal requires attention to following aspects:

5.1 Data: A Key Enabler for Criminal Justice Digital Twins

One of the critical challenges identified in developing a narrative-driven digital twin of the criminal justice system is data quality, availability, and integration. Without comprehensive and reliable data, efforts to replicate events and interactions within the criminal justice system would fail to accurately represent reality.

Participants in this study highlighted various issues, such as difficulties in data exchange, unstructured data formats, lack of standardization, and the absence of essential data recordings within the US criminal justice system. The criminal justice system data are made of multiple sparse one-dimensional systems, and the captured data does not include the social factors that we are looking for. This challenge was also reported by Yossef Ravid and Aharon-Gutman[2023] in developing social urban digital twins. Building digital twins requires capturing data with a broader context, while actors in the system are mostly interested in investing in data collection for immediate measurement. Thus, the data for a broader context is not being captured, and it brings discrepancies between narratives of reality and narratives of the data.

A digital twin can be developed for different contexts. For instance, it could be secure and subject to authorized use only in some contexts while open with anonymized data in other contexts.

The criminal justice system has confidential and private data, and reaching agreements to share data between different actors, and reaching agreements about what to count and capture is another power dynamic challenge. While complete unrestricted open data is "dead upon arrival" due to privacy concerns, what is needed is mechanisms for data quality and protection.

Open data initiatives would not only facilitate the development of models that better assist criminal justice practitioners in decision-making, but also enable public defenders, researchers, and activists to advance accountability and transparency within the system. By making data more interoperable, stakeholders can better examine and challenge systemic issues, such as biases and disparities in policing and sentencing practices.

The importance of open data in the criminal justice context has been echoed in previous research. For example, Elbashir et al.[25] emphasized how open data can improve transparency and enable the public to scrutinize the inner workings of the criminal justice system. Open data allows for a more thorough examination of how cases proceed through the system and how decisions are made at various stages. Furthermore, the challenges associated with data accessibility are not unique to the United States criminal justice system. Pope et al.[81] identified similar issues in the United Kingdom, such as poor data quality, significant data gaps, inadequate linking of relevant data across organizations, and difficulties for external researchers in accessing data.

To tackle these issues, Pope et al.[81] advocated for the adoption of data justice policies that promote open justice. Such policies aim to improve data quality, bridge data gaps, facilitate better data linking across relevant organizations, and make data more accessible to external researchers. By implementing data justice practices, criminal justice systems can create an environment that fosters transparency, accountability, and evidence-based decision-making.

While, the development of effective digital twins for the criminal justice system heavily relies on the availability and quality of data. Adopting open data practices and data justice policies is crucial for building transparent, reliable, and insightful digital twins that can drive meaningful reforms and promote justice.

5.2 Ethical Considerations and Social Impact of Digital Twins in the Criminal Justice System

The potential deployment of digital twins in criminal justice systems raises critical ethical considerations and social impacts that require careful attention, as outlined below:

5.2.1 Privacy and Data Security. Unlike digital twins in industrial systems, which mostly deal with data related to products and manufacturing processes, building a digital twin of the criminal justice system relies on human data, requiring greater consideration of data privacy and confidentiality than ever before in the development of digital twins. The ethical implications of developing digital twins for criminal justice systems extend far beyond conventional concerns of data privacy and security. While, we aim to maintain the privacy of data in our systems, we need to consider that how our data driven approaches capture the reality, and how our system can miss what happens in the reality.

Digital twins represent new technological facilities that mediate how justice is administered. Previous studies have highlighted sensitive ethical considerations when it comes to developing a digital twin of society [38]. Collecting and maintaining data for a digital twin can impact the liberty of society, as previous work has mentioned the autonomy of people [38, 46].

For example, Huange et al.[46] considered the use of digital twins in developing personalized medicines, and noticed the need for considering privacy and security due to the human nature of the system.

In alignment with mentioned previous studies, the focus group participants in this study also emphasized the importance of addressing ethical factors when developing a digital twin of the criminal justice system. They raised concerns about privacy, security, and civil liberties, recognizing that dealing with personal information and case details in a digital twin requires careful consideration. As one participant noted, "two big pieces will be privacy and security" and "you have personal information for people and cases."

These findings underscore the need for incorporating robust data protection measures and ethical guidelines in the development and implementation of digital twins in the criminal justice domain.

5.2.2 Risk of Datafication of Justice. The other critical ethical consideration in developing digital twins for criminal justice is the risk of over-simplification. Since "each situation is very unique" (P2). Researchers warned about the potential risk associated with excessive state driven data production, which is known as datafication of justice in neglecting actions to address the root causes of social problems such as inequity[6]. There are questions about how machines can process data more objectively than human, and model the reality[42].

As digital twins rely heavily on data, and biases in collected data can significantly influence the dynamic models and machine learning algorithms used to predict scenarios. This underscores the need for future research focused on developing robust data justice policies.

In addition, there are open questions about how we can address the void of data that is usually missing from the organizational need standpoint. In other words, if digital twin systems aims to reflect the reality and serve the society, the safety, and privacy, and freedom of people are not the only fundamental challenges, we need to capture elements about the internal feeling of people to ensuring having moral judgment about the problems that stories which would be generated by digital twin of this social structure.

5.2.3 Surveillance and Institutional Control. The implementation of digital twins of the criminal justice system introduces complex power dynamics through enhanced surveillance capabilities. While such visibility promotes accountability and fairness, it can create problematic power asymmetries. As P2 emphasized, It creates tension between "public safety in one side", and "people's liberties" which exemplifies the Focault's perception toward the surveillance system. Creation

of digital twin systems can potentially give the feeling of being observed to all parties in the system, and it will change the power dynamics in an unpredictable way, while initially it can stop actors from prioritizing their own interest, there is a risk to constrain the agency of actors in pursuing public safety, and the same time perceived feeling of freedom by citizens.

One illustrative example of the transformative effect of new surveillance technologies on individual behavior is the extended chilling effect observed in social networks, where users constrain their offline behavior due to fear of being observed in online environments through others' digital recording devices[62]. Similar to this phenomenon, digital twins in the criminal justice system could create a pervasive sense of surveillance that extends beyond the system's direct scope.

This panoptic effect raises important questions about the balance between institutional effectiveness and individual autonomy. Just as social media users modify their behavior in anticipation of potential surveillance, actors within the criminal justice system might begin to self-regulate in ways that prioritize appearances over effective justice administration.

Historically, police departments were focused on crime prevention which is a hardly assessable objective[61]. The ethical implications of predictive surveillance in policing resonates themes explored in Steven Spielberg's "Minority Report" [98], where law enforcement utilizes precognitive technology to prevent crimes before they occur. While digital twins don't claim supernatural foresight like the film's "precogs," their data data driven simulation raise questions about determinism versus[88] free will in behavior of actors.

5.2.4 Authority and Agency. Approaching this through Structuration theory's perspective [33], digital twins manifest a clear example of structural duality where the digital twin systems enable and constrain social practices simultaneously, reshaping both individual agency and institutional structures through their recursive interaction. The digital twin would create a complex feedback loop where system actors' behaviors shape the data and models, which in turn influence future behaviors. For example, if judges know their sentencing patterns are being modeled, they might adjust their decisions to align with predicted "optimal" outcomes. It also can change the relationship between actors.

While current judicial power often stems from discretionary judgment and tacit professional knowledge, the introduction of digital twins creates a complex redistribution of authority through the datafication and quantification of decision-making processes. Even more, the potential for empathy building through AI-generated narratives from quantitative data within digital twins could redistribute interpretative power. In one hand, these narratives might oversimplify complex situations or reinforce existing biases in the data, and in the other hand, they make complex decisions more accessible while introducing new forms of interpretation and meaning-making.

5.2.5 From Data Bias to Bias Mitigation. The duality of structure can describe that what we identify as a "bias feedback loop" which refers to the process that biased practices generate biased data, which then shapes future decisions through the digital twin's systems. As P1 noted: "The system is being built based on the not reported data," highlighting how data gaps become structurally embedded. This poses the risk toward not just extending but also reproducing "algorithmic oppression"[73] in the criminal justice context. These are biases that exist in broader society but had been partially controlled through existing judicial procedures and safeguards. But biased data collection can reintroduce these biases to the system, and increase bias toward marginalized population[31].

Yet this same structural duality also offers transformative potential. Building digital twins of society has the unique capability to identify bias by highlighting varying enforcement of the law, different approaches in processing cases, and making competing narratives visible. The digital twin systems has the potential to reinforce fairness instead of bias in

the society, and change the human behavior in daily life. For example, if judges can see patterns showing unconscious bias in sentencing across similar cases, they may naturally adjust their decision-making to be more consistent and fair. As prosecutors see varying charging patterns across jurisdictions, they may standardize their approaches to reduce disparate treatment. This cycle can extends beyond the formal justice system to influence broader social behaviors and attitudes. The visibility of patterns and actions could help reduce prejudices and stereotypes in the general public. But in order to reach toward this goal, we need to employ strategies for mitigate bias in the system. As [67] suggested, AI is holding a mirror to our society. Even if the AI that is driving digital twin systems is biased, it is also mirroring the bias to us. If "we keep human in the group, and computers in the loop" [92], we can gain new insights about bias, and mitigate the risks. By auditing data and employing explainable AI in digital twins, we can work toward a system that not only reveals societal biases but helps actively correct them. Regular algorithmic audits can identify potential sources of bias in training data and model outputs. Employing explainable AI make decision-making processes transparent, and allow stakeholders to understand how conclusions are reached and intervene when necessary.

5.3 Decision Sandbox for Prosecution and Policing

The focus group discussions revealed the potential of digital twins as a sandbox for testing experimental situations and evaluating the impact of different interventions in the criminal justice system. Participants recognized the potential role of digital twins in public safety planning, policing strategies, and prosecution decision-making.

By leveraging agent-based modeling and social dynamics simulation, digital twins can create a virtual environment where decision-makers can define and test various scenarios . This sandbox approach allows for the exploration of alternative strategies and interventions. Consequently, it can enable criminal justice organizations to anticipate and mitigate potential risks and unintended consequences.

In the context of policing, digital twins can be used to facilitate the testing of different policing strategies, such as resource allocation approaches , and crime prevention measures. By simulating the impact of these strategies on public safety outcomes, police departments can make more informed decisions and optimize their approaches to maintaining order and reducing crime.

Similarly, in the prosecution context, digital twins can provide a platform for testing alternative case strategies, plea bargaining scenarios, and sentencing options. By modeling the potential outcomes of different decisions, prosecutors can make more informed choices that balance the interests of justice, public safety, and resource efficiency.

The use of sandboxes in digital twins has been successfully demonstrated in serious game-based applications [114], highlighting the potential for interactive decision-making support. Thus, future work can study the benefits of applying a sandbox approach using narrative-based interfaces in the criminal justice domain. This approach could potentially overcome the difficulties associated with high-fidelity representations while still capturing the complex social dynamics and contextual factors that shape the system.

Additional studies can examine interfaces that utilize generative AI and large language models to present sandbox environments as narratives. Researchers could investigate how these models can summarize, extract, and generate information for users in a story-like way and how it can potentially facilitate information processing and user engagement. Conducting these studies can provide insights into the effectiveness of narrative-based interfaces in enhancing user understanding of complex information and supporting more informed decision-making in critical social domains such as criminal justice.

5.4 Efficiency and Resource Management in Criminal Justice

Participants highlighted how a digital twin of the criminal justice system can provide a comprehensive view of how cases are handled and how human resources are involved in and assigned to tasks related to case management. It can help judiciaries and lawmakers to evaluates court and judge performance, tracking case processing efficiency, and providing real-time insights into the state of the system.

Similar to how applying digital twins has helped industries observe and optimize their operations [14, 21, 104], the application of digital twins to the criminal justice system necessitates the modeling of processes and can create opportunities for observing and optimizing processes in this domain.

5.5 Bridging the Gap: HCI an Approach for People Centric Digital Twins

Previous studies have drawn parallels between the criminal justice system and supply chain management [20, 90], applying supply chain management concepts to criminal justice. However, the focus group discussions in this study revealed the importance of recognizing the unique aspects of human behavior and interactions in social structures like the criminal justice system.

Participants highlighted the limitations of directly applying industrial approaches to complex social issues like criminal justice. As one participant noted, "if you only have a hammer everything is going to look like a nail, so treating people with the same logic...". This emphasizes the need to consider the distinctive characteristics of social systems, which involve a plethora of variables and interactions that may not be present in industrial settings.

Code relation browser tool of MAXQDA revealed the overlapping between people challenges, and HCI. As suggested by Vainionpää et al.[106], adopting a socio-technical system perspective is crucial when adapting digital twins for use in complex social systems like the criminal justice system. This approach recognizes the interplay between technology and social interactions that are outcome of human agency , such as behavior, perceptions, a norms. The role of HCI practices such as user centered practices to advancing criminal justice was previously highlighted by Nigatu et al. [72].

The findings align with those of Vainionpää et al. [106], who conducted a literature review on the current understanding about digital twin concept in HCI. They noted that while HCI researchers have begun working with digital twins, there is a lack of critical perspective regarding the data-driven nature of digital twins and its implications for design [106]. They suggested that HCI has the potential to benefit from interdisciplinary collaboration and research on "human behavior and sociology" to better understand human factors [106].This aligns with the recommendations of the National Academies of Sciences, Engineering, and Medicine [71],which emphasized the importance of considering human-digital twin interaction in designing digital twins.

To effectively adapt digital twins for use in the criminal justice system, it is essential to adopt a socio-technical systems perspective. This perspective recognizes that the development and implementation of technology are deeply intertwined with social structures and human elements. By considering these factors, the researchers can move toward a better understanding of the complex dynamics within the criminal justice system and consequently interactive systems that represents digital twins that can present a more accurate outcomes , and enhance decision-making in this context.

Furthermore, HCI as an approach can provide valuable insights into the design of digital twins for criminal justice. Participants emphasized the importance of considering the interaction effects between different stakeholders, each with their own interests and objectives. HCI research can help identify and address these diverse needs, ensuring that digital twins are not only technically sound but also user-friendly and conducive to effective decision-making. To apply HCI principles in the design of digital twins for the criminal justice system resonates with the findings of Vainionpää et

al[106]. They argue that HCI approaches, such as user participation, interdisciplinary collaboration, and research on human behavior and sociology, can help address the challenges arising from the fundamental characteristics of digital twins.

Additionally, HCI theories can significantly contribute to the development data visualization, storytelling, and transparency, and consequently, enhancing the informability and usability of digital twins in the criminal justice context. This approach aligns with the findings of Riley et al. [82], who emphasize the growing importance of data visualization in improving decision-making and operational efficiency within the criminal justice system.

Studies about storytelling and narrative in human information interaction can transform information about the criminal justice system from numbers to stories to make the critical insights accessible and meaningful to various stakeholders. Design methods of user centered studies can be employed and test out innovations, and speculating the future of information systems. Consequently by developing digital twin of criminal justice system, this system can be used recursively to move toward a human centered legal system[40] by working as an instrument for understanding how policy proposals can enhance' people outcomes, and access to justice[40].

As the people involved in the cases, and their competing narratives are the center of the criminal justice processes, the HCI can contribute to the development of the criminal justice digital twin by bringing the data driven personas. Data-driven personas are representative characters created based on aggregated and deidentified data from real individuals without being linked to specific person[120]. Personas are naturally empathy building for stakeholders through storification, which aligns well with presenting the human stories behind the numbers, giving meaning to data and showing that people in the criminal justice system are not just statistics, but individuals with unique experiences, backgrounds and circumstances that shape their interaction with the system.

Earlier we mentioned the ethical risk of oversimplification, and threats of not capturing the human elements of narratives and stories of people who enter the criminal justice system. It could open a new area of research for exploring empathic computing paradigm. Although the research in empathic computing mostly focused on using sensors to measure feeling such as stress[10], this paradigm can provide a potential avenue that aims to understand human states and feeling in capturing data about identifying bias, and disparities in the criminal justice system.

In essence, applying digital twins to the criminal justice system requires a departure from conventional industrial approaches. As we move toward exploring this new horizon of digital twins, HCI methods such as participatory and speculative design can allow researchers and practitioners to consider alternative socio-technical systems and find potential challenges in this endeavor. This presents a novel but challenging area for HCI researchers to engage with and contribute to the advancement of digital twin technology in social and behavioral domains.

5.6 Power Dynamics of Digital Twin in Criminal Justice System

Digital twin systems carry a transformational impact on organizations[113]; any efforts toward transformation will impact the power dynamics within organizations and their environment. The criminal justice system is not an exception, and the transformative impact of the digital twin on this social structure is critical for all the people who are directly and indirectly involved with the criminal justice system. These transformation, can increase friction between stakeholders, and change the power dynamics.

From technology adaption standpoint, the resistance to change would be a barrier, and it stems from multiple interrelated sociological factors. At the institutional level, the justice system has historically valued professional experience and discretionary judgment. As P4 noted in the focus group, there's concern about how digital twins might 'evaluate and threaten the discretion of some of these actors.' This resistance reflects what Lipsky[2010] identified as

"street-level bureaucracy" where frontline professionals resist technologies that might constrain their authority. In this regards, Brayne [2020] discussed how police departments found that technological adoption often faces resistance when it threatens established professional expertise and autonomy. This resistance to change is not just limited to policing, and it is reported in studies about criminal justice reform[116], and it complicates the efforts for developing and deploying digital twin systems.

5.6.1 Competing Narrative . Different stakeholders within the criminal justice system maintain distinct narratives that reflect their perspectives, interests, and institutional positions. Law enforcement might use the digital twin to support their investigative narratives, while defense attorneys might leverage it to challenge official accounts. The critical question becomes who can access and influence these digital twin narratives, creating various socio-technical and sociopolitical imaginaries with different power balances.

The creation of digital twin systems raises fundamental questions about open data:

- Would there be public dashboards for narratives?
- How can the system accommodate multiple, sometimes conflicting narratives?
- How might access be structured to prevent misuse while promoting transparency?

5.6.2 Democratization vs. Power Concentration. The potential of digital twins to either democratize or extend the power imbalances in the justice system depends mainly on implementation choices. While digital twins could theoretically provide unprecedented transparency, make the state of the system more accessible for the court of public opinion, and potentially pave the way for improving the system by addressing public concerns through electors and policymakers, there is a potential risk of opportunistic approaches in using systems to hide facts. One potential way to move toward transparency and democratize justice is to provide an opportunity to see and compare multiple narratives by considering the history of victims and defendants; this approach can potentially reduce power imbalances.

6 LIMITATIONS

This exploratory study employed a focus group methodology, which is valuable for gaining initial insights but has certain inherent limitations. The first limitation of the study is the small sample size of the focus group participants, which may have constrained the discoveries regarding digital twins in criminal justice. A larger and more diverse sample of participants could potentially reveal additional challenges, opportunities, and use cases that were not identified in this study. Future research should involve a larger and more diverse experts to validate and expand upon the insights gained from this study.

Additionally, the demographic composition of the participants may limit the applicability of the findings to other contexts and jurisdictions. The perspectives and experiences of the participants may be influenced by their specific roles, expertise, and the criminal justice systems they are familiar with. The participants of this study were from home rule states, as a result, the findings may not be generalizable to all criminal justice systems globally, as each jurisdiction may have its own unique characteristics, challenges, and opportunities.

Another limitation of this study is its scope, which primarily focuses on the narrative of cases in criminal justice. Consequently, the technologies and solutions discovered through the focus group discussions are largely occurred around the LLMs. The trending popularity of LLMs at the time of this study may have influenced the emphasis on natural language processing solutions. However, the development of a comprehensive digital twin of the criminal justice system may require the integration of various other data types and technologies beyond natural language processing.

The other limitation of this study is the potential for researcher bias, given their specific backgrounds and perspectives. While the researchers attempted to minimize this bias by employing in-vivo codes during the open coding stage and using inductive analysis to ensure that the work accurately represented the views of the focus group participants, the possibility of bias influencing the interpretation of the data cannot be entirely eliminated.

7 FUTURE WORK

Overall, the findings from this exploratory study present several questions for both theoretical development and practical implementation research:

Researchers can use the thematic road maps to identify and prioritize specific research questions or hypotheses related to the challenges, benefits, and approaches of using digital twins in the criminal justice system. For example, the maps can help researchers focus on the most critical challenges or promising opportunities identified by the six participants in this study.

Table 5 outlines the key areas for future work identified in this study.

Area of Future Work	**Description**
Data Concerns	There is a lack of understanding of the current criminal justice data landscape, including existing gaps and effective solutions to address these gaps.
Digital Twin Privacy & Ethics	The full scope of ethical implications and potential biases in criminal justice digital twins is not yet known. There is a need to understand how to develop comprehensive ethical guidelines and effective bias mitigation strategies specific to this context.
Human Digital Twin Interaction in Criminal Justice	There is a lack of clear understanding of how to effectively employ behavioral factors in development of digital twins that simulate social behaviors of human actors in criminal justice.
Digital Skills and Training	The current level of understanding and digital skills related to digital twins among criminal justice practitioners is unknown.
Use Case Exploration	The potentials and limitations of digital twins in various criminal justice applications (e.g., decision-making, intervention testing, performance evaluation) require further user-centered design research. There is a need to investigate how stakeholders interact with and interpret these digital representations, and to understand the usability challenges, cognitive impacts, and ethical implications associated with each use case.

Table 5. Areas of Future Work in Criminal Justice Digital Twins

Data concerns was a observed as a critical challenge, and future research should focus on assessing the current landscape of criminal justice data, identifying gaps, exploring solutions to address data gap to promote data justice.

The development of a digital twin in the criminal justice system heavily relies on access to comprehensive data from various actors involved in criminal cases, including offenders, police officers, prosecutors, and judges. This data is essential for recognizing inequalities, biases, and inefficiencies within the system. However, collecting and utilizing personal data in the criminal justice domain presents significant challenges, as the adaptation of open data policies to this sensitive context is complex, as it can lead to potential unintended consequences for all involved parties.

To address these challenges while still leveraging the power of data to promote transparency, accountability, and social justice, authors recommend of a pilot study to establish a public repository of data-driven personas in criminal

justice through a co-design process. . Utilizing them in criminal justice can encapsulate typical backgrounds, actions, and behaviors of actors within the criminal justice system. By clustering similar characteristics and experiences, data-driven personas can provide valuable insights into the criminal justice landscape without compromising the privacy and security of individual actors. This approach not just provides a holistic view of a dynamics of criminal justice, but it could enable scrutinizing policies and laws without putting individuals in the spotlight. For instance, instead of highlighting a specific person's case, a data-driven persona could represent a typical experience of someone with a particular background or illustrate a specific challenge within the criminal justice system for a group of people or a victim of a specific type of crime dealing with the legal process.

In addition, further studies should explore effective data protection measures to establish comprehensive ethical guidelines for digital twin implementation in the criminal justice system. Future work must address methods to identify and mitigate potential biases in the data used to develop these digital twins.

Future work could be done to address the human aspects that are needed in social and behavioral sciences when applying digital twin technology. Specifically, conducting research to define a human-centered framework for developing digital twins can be another area of future work.

The discussion about efficiency of criminal justice system also made the researchers interested in researching about the applications of digital twin in governance and electronic government strategy.

Moreover, there is a need to assess the current level of understanding of digital twins among researchers and practitioners in the criminal justice domain. Parmar et al.[78] highlighted the need for new digital skill training for adapting digital twins in organizations. Future research should focus on conducting surveys or interviews to gauge the existing knowledge and identify specific areas where education and training are needed. Based on these findings, efforts can be made to develop targeted educational resources and curricula to raise awareness and provide knowledge about the potential benefits, challenges, and applications of digital twins in the criminal justice system.

Finally, each use case recognized in this study can also be an area for future study and exploration. The potential use cases identified, such as decision-making, testing interventions, evaluating system performance, predicting outcomes, and mimicking scenarios, could be further investigated and developed as separate future research endeavor.

8 CONCLUSION

This exploratory study makes significant contributions to understanding the potential applications and challenges of innovations by digital twins in the US criminal justice system. The major contributions of this study are the insights about existing and potential challenges regarding the development and possible deployment of digital twins in the US criminal justice system. These challenges include data collection, resistance to change, power dynamics, competing narrative of justice, ethical concerns, and difficulties in simulating human behavior which should be investigated in future works. The study also highlights probable opportunities that digital twins can create for supporting decision-making for public safety, advancing accountability, fairness, and efficiency in the US criminal justice system.

Additionally, the research identified several areas for future work, beyond the criminal justice system to advancing digital twins in social structures. We invite HCI researchers to study social digital twins to address capturing social dynamics while preserving civil liberties and privacy, presenting human narratives in information systems, and potentially building social digital twins as tools to bring human-centered innovations to traditional social structures and public institutions.

As we move towards more data-driven governance, these practical implications are a step toward the future of information systems in the public sector of democracies and conceptualize the new avenues of research in emerging

areas of digital twin and Human-centered criminal justice. Our exploratory study certainly has some limitations, even though, the study presents insights for understanding how digital twin technology could be leveraged to address critical societal issues by presenting potential scenarios to improve decision-making and consequently enhancing governance and restoring the trust in the national institutions.

Finally, since the first step toward developing digital twins of society is data collection and processing, the researchers recommends that policymakers establish a repository of anonymized personas of actors in the criminal justice system as a pilot study. This would create a foundation for further research and development. This approach has the potential to be applied to other larger social structures to enhance institutional processes.

ACKNOWLEDGMENTS

The authors report there are no competing interests to declare.

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