RESEARCH STATEMENT

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My research lies at the intersection of Computer Science, Computational Social Science, and Social Computing, employing ubiquitous technology to gain insights into human behavior with an emphasis on **mental health and productivity**. Our behavior significantly impacts our health, overall well-being, and productivity in the workplace. Factors like physical inactivity, social isolation, and limited self-awareness contribute to various ailments and diminish our motivation for productivity. Despite numerous theoretical models aimed at understanding and influencing behavior, their efficacy is often limited as they fail to capture the full range of human behavior and the dynamics that emerge within the real-world environment. Technologies like smartphones and wearables, equipped with sensors, provide a continuous, passive stream of behavioral and physiological data, such as sleep patterns and physical activity levels. This passive data collection can be complemented by active user input through momentary assessments, capturing states like mood and cognitive performance. By analyzing these varied data streams, we can develop a more comprehensive and dynamic understanding of individual behaviors in real-world contexts. I am passionate about **harnessing the power of this technology in conjunction with AI** to create tools and insights that empower individuals to lead their lives more fully, fostering an environment where everyone can achieve their best in both personal and professional spheres.

As an interdisciplinary scholar, my research addresses complex social challenges with a focus on mental health. The multidisciplinary experience allows me to combine the human-centered approach of understanding and framing the challenges with a technical and quantitative approach to designing effective interventions and solutions. I employ diverse empirical methods, from extensive longitudinal data analysis, AI, machine learning, and deep learning to targeted interviews and surveys, to examine individual behaviors in various contexts. For instance, my work includes understanding the impact of COVID-19 on student behavior [1], analyzing the effects of job promotions [2], and even detecting depression through in-the-wild images [3]. Such investigations have enabled me to study the immediate factors influencing behavior and its evolution over time within individuals, leveraging the longitudinal nature of ubiquitous sensing studies and developing innovative methodologies and frameworks. My contributions range from **uncovering digital markers of health and risk behavior** to advancing translational science with more **personalized and timely intervention models**. The impact of my work transcends the academic environment. For example, my studies on first-generation college students [4] and the effects of COVID-19 [1] offer valuable insights for shaping educational policies and student support strategies. Similarly, my foundational research into cybersecurity worker burnout [5] informs organizational policies, providing actionable recommendations for management.

Initially, my research concentrated on the implications of ubiquitous technology in everyday life. Over time, it has broadened to address a spectrum of societal issues, including studying individual resilience and behavior amidst societal challenges [1, 6], creating generalizable models for diverse populations [7, 8], and focusing on the unique experiences of first-generation college students [4]. My research has yielded publications at top-tier Human-Computer Interaction (HCI) and Digital/Mental health venues, such as *ACM CHI, IMWUT/UbiComp, CSCW (these three venues are collectively considered to be the top 3 conferences in HCI field), Pervasive Computing, and the Journal of Medical Internet Research.* I have collaborated successfully with researchers in academia (Dartmouth, University of Washington, University of Notre Dame, Georgia Tech, MIT, UCSD, Washington University) and industry (Microsoft Research). These interdisciplinary engagements, spanning psychology, brain sciences, business, and engineering, have significantly enriched my research, providing a multifaceted perspective on the interplay between human behavior and technology. In summary, my research seeks to understand the intricate patterns of human behavior and strives to apply these insights in meaningful ways to improve mental health and productivity in our society.

In the sections below, I showcase my key works organized by themes, all centered around mental health and well-being. Collaborations with mental health experts have been pivotal in these works to ensure our technology is both applicable and ethically sound. I end with some challenges in the field and my future research directions.

Work-Life Dynamics

Initially, my PhD research focused on the dynamics of work-life balance. In my UbiComp 2020 study [2], I investigated the effects of job promotions on information workers' physiological and behavioral patterns, marking the first use of mobile sensing in this context. Analyzing data from 141 workers, the study unveiled significant gender-based differences post-promotion. Notably, female workers exhibited increased stress during work hours, in contrast to their male counterparts. This research also showcased the potential of mobile sensing data to detect job promotions, providing new insights into how career advancements impact workers differently. In my 2021 Pervasive Computing Magazine paper [10], I delved into how commuting patterns influence workplace performance, discovering key differences between high and low performers. High performers exhibited more consistent work arrival and departure times and higher Heart Rate Variability during commutes, indicating better health and resilience to stress. Conversely, low performers showed higher stress levels during commutes, more phone usage, and less consistent work schedules. My findings suggest that commuting behaviors can be

significant indicators of workplace performance, shedding light on the impact of commuting stress on employee productivity and well-being. This research presents a novel perspective on the interplay between daily commuting and professional efficiency, highlighting the potential of ubiquitous sensing technology in enhancing workplace well-being.

I explored workplace behavior using computer-generated digital activity data during my internships at Microsoft Research in 2022 and 2023. One study focused on the association between workplace rhythms and emotional distress. It was published at CHI 2022 [9] and revealed the significance of variability in daily activities rather than just their frequency. Another study, accepted at CSCW 2024 [5], examined burnout in cybersecurity incident responders. This fundamental research combined self-reports and digital activity data, uncovering differing patterns among burned-out and non-burned-out individuals in work hours and reward structures, among other things. During my 2023 internship, I explored the application of large language models in improving the well-being and productivity of information workers [13]. It included designing and conducting a user study to understand preferences for productivity agents and the development of a GPT -4-powered tool. The tool used digital activity data to enhance workers' self-awareness and help them explore their workplace behavior, comparing preferences between chat agents and dashboard visualizations. Overall, my work has been instrumental in understanding how ubiquitous computing intersects with professional life, revealing critical insights into work-related stress, productivity, and well-being.

Longitudinal Behavioral Studies in Educational Settings

My research in this area focuses on students' behavioral and mental health patterns over time, particularly during critical transitions like college entry and the COVID-19 pandemic.

In the CHI 2022 paper [1], I conducted an in-depth analysis of the behavior and mental health of over 200 Dartmouth undergraduates before and during the COVID-19 pandemic. This study, featured in the Washington Post, revealed a significant shift in student lifestyles, including a 60% decrease in physical activity and a 15% increase in phone usage amid the pandemic. I discovered two distinct groups of students, differentiated by their behavioral changes and mental health during the pandemic. One group showed heightened COVID concerns, depression, and stress in self-reports. At the same time, their behaviors, such as phone usage and sleep patterns, also differed significantly from the other group, highlighting the diverse impacts of the pandemic on student life. In my UbiComp 2022 research [4], I examined the unique experiences of first-generation students at Dartmouth College. Comparing them with their non-first-generation peers, I found several differences in behaviors. For example, first-generation students spend more time in study areas and seldom visit the gym and Greek houses where campus-wide social events and parties usually occur. Furthermore, the study found that although first-generation students face distinct challenges due to socioeconomic factors and support networks, they exhibit resilience, adapting their behaviors for better mental health as the academic year progresses. Our novel deep learning model tailored for first-generation students improved the prediction of mental health indicators, addressing the bias towards the majority in existing models.

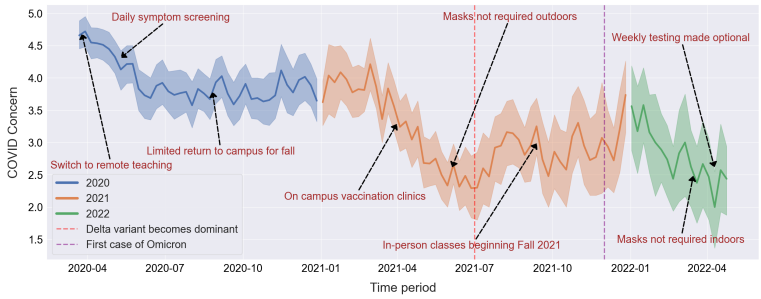

Figure 1: Self-reported COVID concern of students and major campus events.

My latest work, recently accepted at UbiComp 2024 [6], analyzes one of the longest mobile sensing studies in the academic field. Spanning from 2017 to 2022, it captures the complete college experience of over 200 Dartmouth undergraduates. This study provides an in-depth look at the ebb and flow of mental health throughout college years, specifically focusing on social events, exam periods, and the impact of COVID-19 (Figure 1). Our analysis highlights that female students demonstrate higher sedentary behavior and social engagement yet face elevated COVID concerns and lower self-esteem than their male counterparts. Utilizing mixed effect models, I explore behavioral adaptations during and after COVID subsides, offering insights into the 'new normal' for students. Although some behaviors, such as physical activity, are reverting to pre-pandemic patterns, others, like sleep duration and social interactions, have not yet normalized. I also interviewed 15 students, adding a qualitative dimension that captures the diverse experiences and challenges faced during these extraordinary times. Furthermore, we are publicly releasing the de-identified dataset to advance research in this field. This rich dataset offers a unique opportunity for in-depth exploration of mental health and behavioral patterns in college students using mobile sensing and self-reports.

Methodological Reflections and Generalizability in Mental Health Assessment

I've encountered the intricate challenges of using passive sensing data for comprehensive mental health assessments. The complexity of mental health, often defined by subjective diagnostic processes and fluctuating symptoms, makes predicting mental health outcomes based solely on ubiquitous computing technology a daunting task.

My work has explored the generalizability of behavioral models across diverse datasets. In a pivotal paper presented at UbiComp 2023 [7], we combined datasets from Dartmouth College and the University of Washington to test the generalizability of depression prediction models. This study critically analyzed existing algorithms, uncovering their limited generalizability. Our newly developed algorithms, while showing some improvement, still highlighted the overall optimism and limited applicability of current approaches in this domain, achieving a balanced accuracy of just 55.2%. This paper won the distinguished paper award at UbiComp, awarded to the top 1-3% of papers each year. Furthering this inquiry, the UbiComp 2024 study [8] investigates the use of speech-based diaries from mobile phones for detecting suicidal ideation. Our cross-dataset experiments revealed the poor generalizability of existing machine and deep learning methods. We proposed a novel approach, Sinusoidal Similarity Sub-sampling (S3), which improved cross-dataset performance without relying on labeled target data or feature transformation, indicating a potential path forward in this challenging domain.

Another study recently accepted at CHI 2024 [3] examines the potential of opportunistic mobile sensing to detect depression. In this work, we capture non-performative images of individuals using the front camera of their smartphones as they respond to the Patient Health Questionnaire (PHQ) survey (Figure 2), aiming to uncover depression signals in these in-the-wild and naturalistic images. The findings of this study are promising as the classifier shows discriminative power in identifying depressive states. This approach highlights my commitment to capturing and understanding human behavior most unobtrusively and naturally possible, illustrating the strength of mobile sensing in providing insights into mental health in everyday settings.

Each of these studies reflects on the methodological challenges and limitations in mental health assessment using ubiquitous technology. They underscore the need for more robust and nuanced approaches.

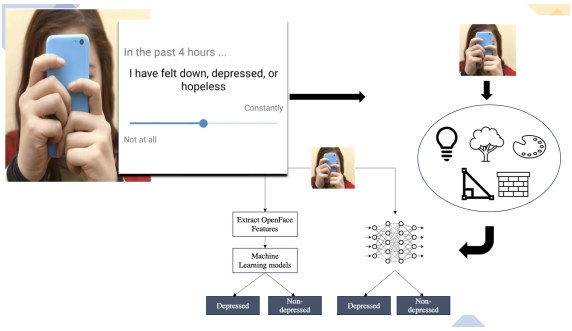

Figure 2: Our app captures photos while users complete the PHQ-8 survey, analyzing image characteristics and training models for depression detection.

Behavior Change through Interventions

In transitioning from understanding behaviors to facilitating behavior change, my recent work has focused on utilizing mobile sensing for intervention-based studies, particularly among individuals with serious mental illnesses (clinical) and college students (non-clinical).

In collaboration with faculty and research staff in psychiatry at UCSD's Center for Mental Health Technology, we have developed a novel, context-aware intervention that combines in-person Cognitive Behavioral Therapy (CBT) with mobile CBT interventions to address social isolation in individuals with serious mental illness. This personalized and participatory approach utilizes mobile sensing data to trigger context-specific therapeutic activities. As shown in Figure 3, we use the GPS sensors and microphones to detect if the user is home or away and around a conversation, respectively. The app fires contextual ecological momentary assessments (i.e., surveys) based on this information. For example, when the participant is home and alone, the app challenges their negative beliefs about social situations (i.e., anxiety and social threat appraisal), and it reminds them of positive experiences they have had in the past. Similarly, when the individual has recently had a social interaction, the app helps them savor the positive aspects of that interaction, and it challenges their negative thoughts about future interactions (i.e., defeatist appraisal). Early results in this 24-week-long clinical trial seem promising. The manuscript is currently under review at Pervasive Computing magazine [11].

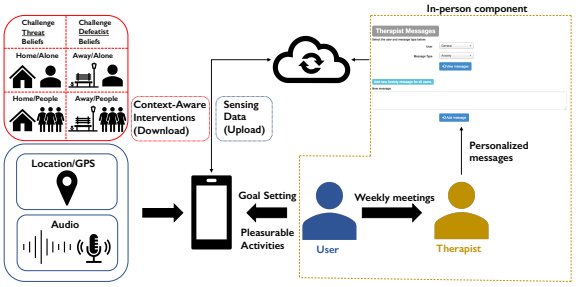

Figure 3: Blended CBT approach using context-triggered mobile interventions and therapist-in-the-loop personalization.

For the final part of my thesis, I am exploring integrating mobile sensing data with large language models to enhance digital journaling [12]. This study involves Dartmouth undergraduates using a context-aware journaling app over a full

term. The app leverages mobile sensing data, like physical activity and screentime, to generate personalized journaling prompts through a large language model. The aim is to investigate whether such context-specific prompts can lead to enhanced personal growth, self-awareness, and emotional resilience compared to generic journaling methods. This innovative approach represents an effort to marry mobile sensing technologies with advanced computational models to support behavioral change and digital health.

Both studies exemplify the transition from merely assessing and predicting mental health to actively inducing positive behavioral changes. They highlight the potential of mobile sensing and its integration with other technologies, including AI, in creating personalized, impactful interventions in mental health and well-being.

Future Research Agenda

My future research aims to advance our understanding of mental health through digital means while being candid about the challenges and ethical implications. It involves a shift towards more holistic data analysis methods and reconsidering how we define success in this field. The goal is not just technical advancement but creating tools and methodologies that are truly beneficial and responsible within a mental health context.

1. **Expanding beyond prediction:** I plan to expand beyond predictive modeling to understand mental health and behavior better holistically. This approach includes exploring unsupervised learning and exploratory data analysis to uncover new insights from complex datasets. My research has demonstrated that while we can sometimes predict certain outcomes, our models fall short in just as many instances. This realization doesn't reduce the value of our efforts but rather highlights the need for meaningful interpretation and decision-making based on thoughtful analysis. Throughout my investigations, I've observed the propensity for enthusiasm to eclipse pragmatism. It's tempting to imagine a world where passive sensing data could offer comprehensive mental health assessments or predict behavioral outcomes precisely. However, the reality is more nuanced. While rich in data, these technologies often intersect with ill-defined psychological metrics and complex human variables. This intersection presents several challenges that we are only beginning to navigate. There's a compelling need to pivot towards generating actionable insights and fostering human-technology collaboration. My work with context-aware interventions and journaling reflects this shift, focusing on how we can leverage technology to support, rather than define, mental health strategies.
2. **Harness the power of recent advancements in AI and Large Language Models:** The potential of technologies like large language models in tandem with ubiquitous computing holds promise for customized, nuanced applications that respect the complexity of human experience. Here, the goal is not to over-promise the direct estimation of mental health states but to use these advanced tools to support well-being in ways that are tangible, effective, and grounded in reality. There are many challenges to be explored in this area, including how to customize language models with the kind of technologies we work with.
3. **Collaborative Healthcare Models Using Ubiquitous Computing:** I'm also interested in researching collaborative models where ubiquitous computing tools are used in tandem with traditional healthcare services. Despite the advancements in ubiquitous computing for mental health research, there remains a significant gap in their practical application by clinicians. This disconnect often stems from an overemphasis on prediction in computational research while overlooking critical aspects like design, HCI, and trust-building essential in clinical settings. To bridge this gap, I am keen on collaborating with healthcare professionals to develop systems that effectively merge digital tools with conventional healthcare methodologies. I aim to create platforms where technology complements clinical expertise, aiding diagnosis, treatment planning, and patient monitoring. Such systems could enhance healthcare delivery by providing clinicians with nuanced data and insights while also ensuring patient trust and comfort with these digital interventions. This direction is related to my effort to move beyond mere data prediction and towards a more holistic, integrated approach in healthcare, where ubiquitous computing tools are not standalone solutions but part of a collaborative, patient-centered healthcare ecosystem.
4. **Continue Exploring Productivity and Student Life:** Building on my previous work, I aim to explore how ubiquitous computing can impact areas like productivity, performance, and student life in non-clinical settings. Understanding the relationship between technology, mental well-being, and performance in the everyday lives of students and professionals can offer insights into how digital tools can be used to improve life quality and efficiency. It will involve studying behavioral patterns, stress factors, and coping mechanisms in academic and professional environments to develop interventions that support mental well-being and productivity.

Conclusion

As I move forward, my research will continue to be shaped by past experiences and driven by the desire to tackle vital and achievable challenges. Recognizing the limitations of current approaches, my mission is to identify areas where significant and constructive impact can be made in the field of mental health, productivity, and general well-being.

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