HCI-HPR

Sponsored by Sheffield Hallam Alumni,
DOI: 10.5281/zenodo.11209046

Advancement in Human Computer Interaction and Human Physiological Modelling

ISSN/ISBN-10: 1-100-22302-9

Predicting Optimal Arousal of Affect State to Virtual Scene.

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Abstract

Research in affective computing is now offering the design of closed-loop systems that offer real-time assessment and manipulation of the users' affective state and cognitive response by developing adaptive environments that respond based on a rational and strategic scheme for real-time changes in both affective and cognitive incentives. The main aim is to lead the users to sub-optimal cognitive and affective states based on an optimal state that augments user performance. This paper expurgates the optimal arousal and classification of users' affective state through a virtual scene in time by creating a module that utilises a touch screen for reading the emotional response of the users based on the moisture content in reaction to virtual stimuli. A closed-loop analytic tool was designed for analysis and reads the physiological response (Skin conductance response (SCR), Skin temperature (ST)) and its correlates to user activity. The optimal and tonic phase of the Electro-dermal activity (EDA) (SCR) can be detected by activating the command buttons holding the modules and input parameters. Error in EDA on optimal parameter predictions was computed and discussed in the result section.

Keywords: Electro-dermal activity, Skin temperature, Pupil changes, Moisture content, Optimal arousal state, Tonic and Phasic changes

Accepted: 18th January, 2024
Revised: 16th March, 2024
Published:10th July, 2024

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1 Introduction

The current trend in research based on affective computing is now moving towards designing closed-loop systems that are capable of offering a real-time assessment of users' affective state and cognitive response by designing adaptive environments that are capable of responding in both rational and strategic fashion to real-time changes in affect state of users' motivation and cognition. The main aim of this area of research is to advance the user from sub-optional cognitive and affective states to a more optimal state that enhances user performance. In other to achieve this, there is a vast need for assessment of the optimal affective and cognitive state and also the observed state of the user.

Research has investigated assessing these states (Optimal Arousal and Cognition) by focusing on their close relation to user cognitive performance. The methods in the research make use of the virtual reality Stroop task (VRST) from the virtual reality cognitive performance assessment (VRCPAT) to identify the optimal arousal level that can serve as the cognitive state goal. Three different types of stimuli were presented, both with distinct arousal levels in the VRST. When the reaction time is used as a performance measure, the three stimuli presentations elicit the optimal arousal for most of the subjects and the results show high classification rates that are achieved when a support vector machine is applied as a classification metric for a psychophysiological response.

The research also reflects advanced progress toward the implementation of closed-loop affective computing systems. One of the novel methods presented in this paper is using the touch screen as a metric that reads in and records the physiological response of users from electrostatic field contact with moisture content cursed by electrical changes of the skin, especially from the fingertips. The proceeding section talks about research areas that deal with touch screen mechanisms for user computer interface design.

2 Literature Review

One of the ultimate goals of furthering research interest in the human-machine interface is to give touch devices the ability to provide users with a feeling of richer touch-based experience and also as a base to read the emotional response from the skin. This can also provide the technology with the ability to mimic the feeling of physical objects of stimuli presentation. Hipwell [11, 22, 28, 17, 26, 24, 9, 14, 1] in her work shared examples of potential implementations ranging from a more immersive virtual reality platform to a subtle display interface like those in a motor vehicle dashboard and a virtual e-commerce experience that would let users feel the texture of materials before purchasing and also evaluators can also visualise their emotional response and cognitive state to the products they purchase [13, 15, 25, 29, 19]. One can record users' cognitive state and also observe the user's response by feeling textures, buttons, sliders, and knobs on the touch screen [12].

This process can be used for interactive touchscreen-based displays for a comfortable user experience. The touch screen in its essence is more for the benefit of the user than the interface [12, 31, 3, 21, 8, 5]. With the emergence and refinement of increasingly sophisticated haptic technology, the relationship between the user and the touch device can grow to be more reciprocal. The addition of touch as a sensory input can ultimately enable physiological measuring attributes of the user and also enrich virtual environments and lighten the burden of communication and cognitive response elicitations from users [16, 32, 6]. The electro-wetting effects (i.e. the forces that result from an applied electric field), electrostatic effects, changes in properties of the finger and material property, and surface geometry can enable response reading and changes in the skin surface of the user (Figure 1). Current research is now studying changes in properties, fluid motion, and charge transport in the interface to understand how the touch screen device can be designed to be more reliable with higher performance.

The main goal is to create predictive models that enable designers to create devices with the maximum haptic effect to minimize sensitivity to the user [30, 27] and other environmental factors, early elements implementation for touch screen technology and its application will be common over the next future with new improvements and advancement. The method applied in this paper is to use the touch screen as a metric for physiological response (SCR and ST) and the webcam for an Andriod camera lens as the metric for measuring eye movement behaviour and pupil dilation [10, 20, 7, 4, 18, 23, 2]. The proceeding sections discussed these procedures.

3 Method

The significant addition of touch as a sensory input can ultimately enable physiological measuring attributes of the user and also enrich virtual environments and lighten the burden of communication and cognitive response elicitations from users. The electro-wetting effects (i.e. the forces that result from an applied electric field), electrostatic effects, changes in properties of the finger and material property, and surface geometry can enable response reading and changes in the skin surface of the user (Figure 1). The method adopted in this paper is to use the touch screen as a metric for physiological response (SCR and ST) and the webcam of an Andriod camera lens as the metric for measuring eye movement behaviour and pupil dilation, while they interact with the virtual stimuli environment. The contact with the touch screen reads in the cognitive response of the user while the embedded analytic tool is used to synchronise and visualise response correlates. Six participants were recruited to test the reliability and response detection using the analytical tool.

The task is for the user to interact with the virtual interface presented to them (Figure 2) by placing a real-time image in a virtual setting in a systematic order. The touch sensor reads in their physiological response to the interface and cognitive response to the user experience. The virtual fields are predefined stimulus responses created from MATLAB that enable environmental disinsection as a form of health measure. The cognitive response and optimal response arousal are recorded. The analytical tool is to visualise and detect physiological relationships between the user and the virtual interface. The phasic and tonic changes are detected based on the stimulus setup and baseline estimate.

The users' eyes are calibrated to the virtual screen and it is used to record changes in pupil size in a continuous time interval, the cognitive response is monitored when the user experiences certain difficulties while placing the visual image in the virtual environment. In this process, both task and user physiological responses can be in synchronous representation of the entire user activity. The EDA is the process that which the skin becomes a better conductor of electricity when internal stimuli occur that are physiologically arousing. Arousal is the overall activation and is considered to be one of the dimensions of emotional and cognitive response. The optimal arousal point is a strong predictor of attention and

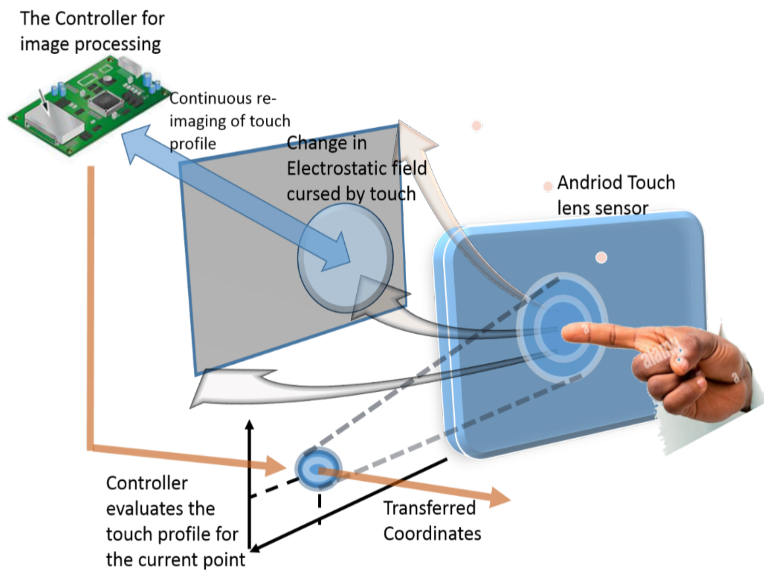

Figure 1: System architecture for touch screen mechanism that reads in user response and input and captured by the micro controller for response interpretation and image processing.

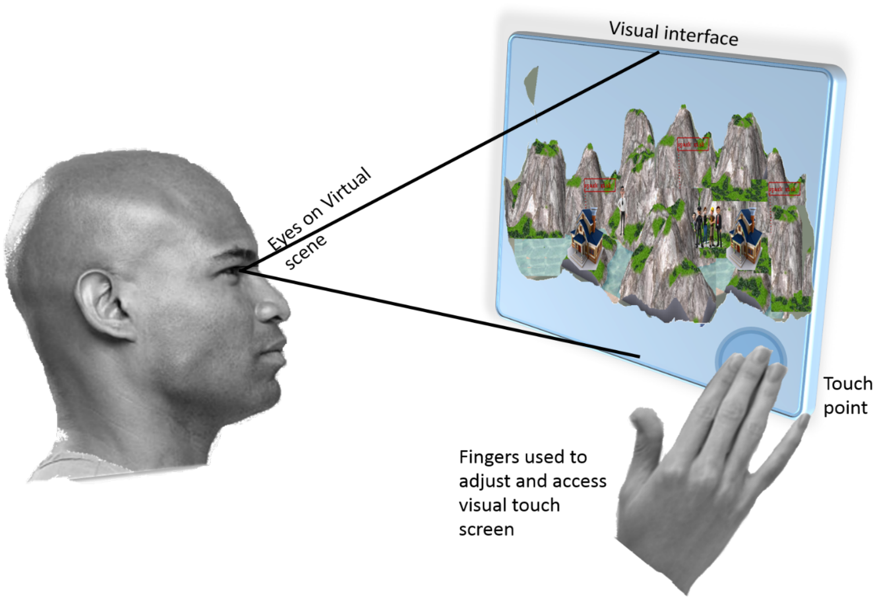

Figure 2: User interaction with the touch screen in a virtual environment.

memory. Sometimes the response can take seconds to arise because it is based on unconscious thought. The baseline is the galvactivator that sets the response to a sensitivity that gives internally generated imagery (Figure 3). The task presented includes events of intense nature and concentration, the arousal level tends to shut up when the response is at its optimal point of interest. The proceeding sections discussed some significant results obtained from this study.

4 Result

Figure 3 shows a captured physiological response of a participant in response to the virtual interactive scene. The mental workload induced by the virtual scene as elicited, the SCR is seen to shoot up through a certain time interval between the latency and stimulus onset. The baseline is used to determine the phasic and tonic changes in the SCR. The reactions gradually decline when a certain problem is solved because the intensity and expectancy are seen to be at the minimal re-

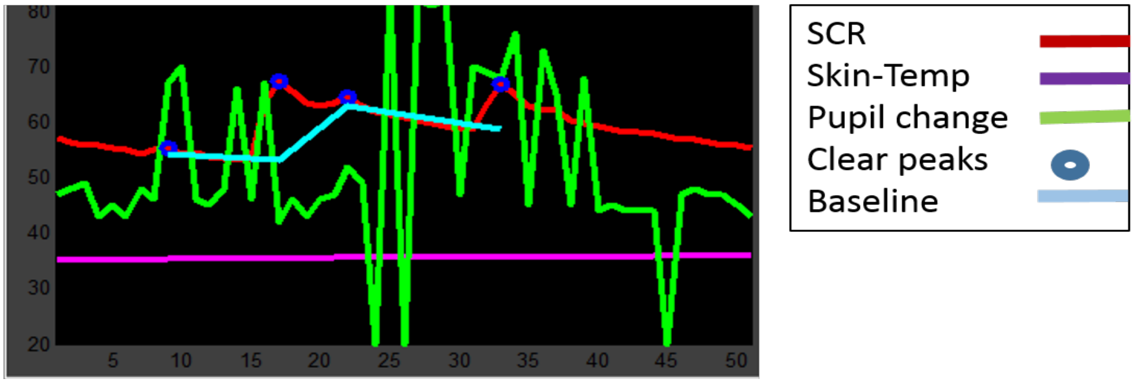

Figure 3: Physiological responses in synchronous order to each other from a participant's session.

sponse. The intensity of task completion is significantly high, and the body naturally overheats for a subtle response. There is a lot of little perspiration in the overall skin conductance (tonic level) which will climb at this stage. The baseline can be reset at this stage and the Skin temperature can be measured at that time interval.

4.1 Pupil response measure

The pupil response is based on the changes in dilation and constriction of the pupil in response to the amount of cognitive workload, if this is in synchronous to SCR which can easily be detected as optimal arousal at the baseline level. Figure 4 shows the window interface of the analytical tool used to analyse and detect both optimal arousal point that correlates to both the tonic and phasic response. The control buttons can be used to view and detect these points and be able to differentiate between these two input parameters. The optimal arousal point detected from the fingerprint at the touchpoint can be visualised at the bottom axes of the EDA panel. This also sets the baseline for the other physiological response attributes. The interface shows an input image of a fingerprint from which the physiological readings are recorded. The model is set in such a way that baseline and offset can be reactivated if no response is detected i.e. the experiment can be started at a different level depending on the availability of the participant and virtual environment. For the detected response time interval, the error is calculated to determine the forecasting of the next response reading from the signal. Figure 5 indicates a plot with aggregate response detected by the analytical tool.

The response detection rate for EDA versa-vis the ST is indicated in Figure 5, this is classified based on the phasic and tonic response for each time interval, most of the records and sessions used a minimal time interval of 60 seconds, to enable faster simulation speed and predict significant optimal arousal at the shortest period as much as possible. The figure represents error detection in the choice of measurement frequency by the placement of fingers on the electrostatic field of the touch screen used. These factors are not ignored because they may result in erroneous measurements with artifacts that contain little or no physiological response. The error detected between the SCR and ST has a low margin at latency in the tonic and phasic classification. This margin is also below the estimated rate of 0.01% and indicates the reliability of the system.

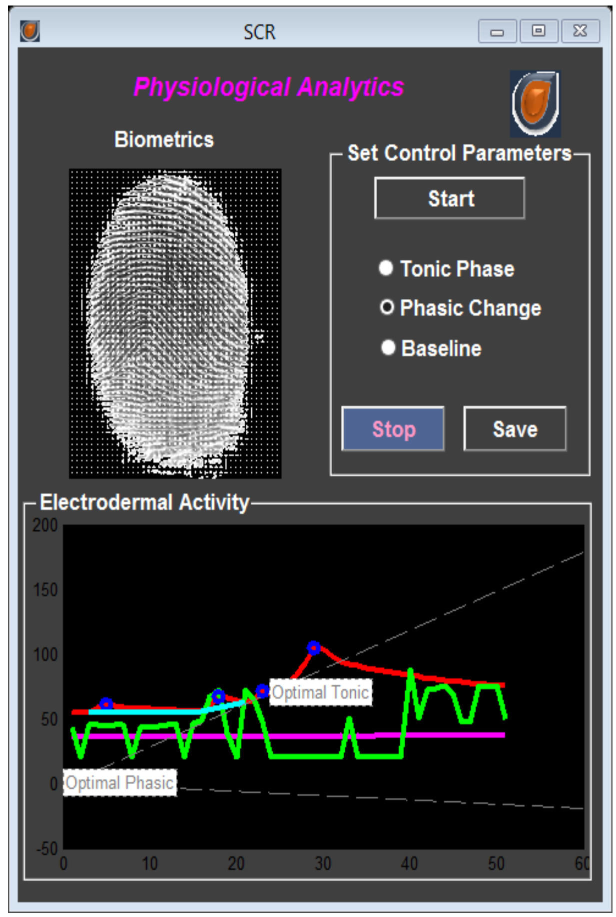

Figure 4: Window interface for the physiological response analyses from fingertips and skin surface.

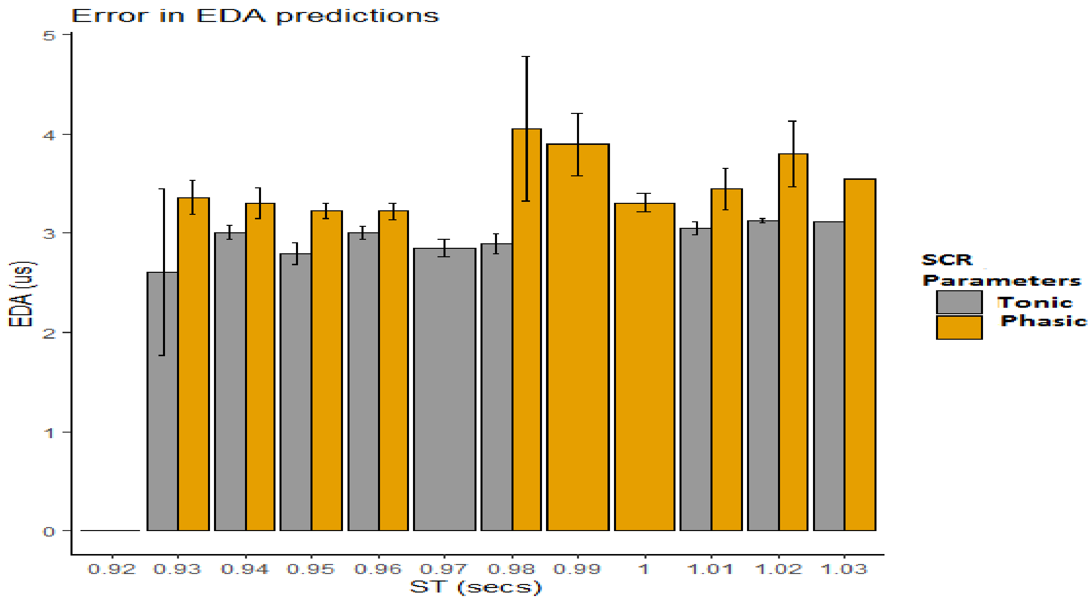

Figure 5: Error in measurement for both SCR and ST at the tonic and phasic classification.

5 Conclusion

The paper attempts to investigate the censoring of optimal arousal and classification of the affected state of users to virtual scène in real-time, the paper detects the optimal arousal and classification of users' affective state through a virtual scene in time by creating a module that utilises touch screen for reading the emotional response of the users based on the moisture content in reaction to virtual stimuli. The response input parameters are classified as phasic and tonic levels depending on the physiological response. A closed-loop analytic tool was designed for analysis and reads the physiological response (Skin conductance response (SCR), Skin temperature (ST)) and its correlates to user activity. The optimal and tonic phase of the Electro-dermal activity (EDA) (SCR) can be detected by activating the command buttons that hold the modules and input parameters. Error in EDA on optimal parameter predictions was computed and discussed in the result section. The future perspective is to try and analyse the optimal response at a different time interval with the virtual scene created as stimuli.

Acknowledgement

The author would wish to thank Nasarawa State University for the sponsor of this paper.

References

[1] Anderson, S. L. (2024). *Ability machines: What video games mean for disability.* Indiana University Press.

[2] Arslan, K. S. (2020). Eye tracking for interactive accessibility: a usability analysis of communication interfaces. Master's thesis, Middle East Technical University.

[3] Blair-Early, A. and Zender, M. (2008). User interface design principles for interaction design. *Design Issues*, 24(3):85–107.

[4] Chung, Y. S. (2023). *Development of a wearable eye tracker.* PhD thesis, UTAR.

[5] Constantine, L. L. (1995). Essential modeling: use cases for user interfaces. *interactions*, 2(2):34–46.

[6] Dai, J. and Moffatt, K. (2023). Enriching social sharing for the dementia community: insights from in-person and online social programs. *ACM Transactions on Accessible Computing*, 16(1):1–33.

[7] Ehlers, J. and Jakoby, A. (1994). Doomscrolling: Eye pupillometry with smartphone camera and a eye tracker.

[8] Fitzmaurice, G. W. et al. (1996). *Graspable user interfaces.* University of Toronto, Department of Computer Science.

[9] Gueorguiev, D., Vezzoli, E., Mouraux, Andre end Lemaire-Semail, B., and Thonnard, J.-L. (2017). The tactile perception of transient changes in friction. *Journal of The Royal Society Interface*, 14(137):20170641.

[10] Heck, M., Becker, C., and Deutscher, V. (2023). Webcam eye tracking for desktop and mobile devices: A systematic review.

[11] Hipwell, D. P. and ENGINEERING, A. F. I. O. T. W.-P. A. O. S. O. (1993). *Developing realistic cooperative behaviors for autonomous agents in air combat simulation*. PhD thesis, Air Force Institute of Technology.

[12] Jansen, Y., Karrer, T., and Borchers, J. (2010). Mudpad: tactile feedback and haptic texture overlay for touch surfaces. In *ACM International Conference on Interactive Tabletops and Surfaces*, pages 11–14.

[13] Kim, H. and Lennon, S. J. (2010). E-atmosphere, emotional, cognitive, and behavioral responses. *Journal of Fashion Marketing and Management: An International Journal*, 14(3):412–428.

[14] Lacher, R. M. (2019). *3D breast surface reconstructions from consumer-grade RGB-D cameras*. PhD thesis, UCL (University College London).

[15] Lee, S., Ha, S., and Widdows, R. (2011). Consumer responses to high-technology products: Product attributes, cognition, and emotions. *Journal of business research*, 64(11):1195–1200.

[16] Li, A., Li, J., Wu, W., Zhao, J., and Qiang, Y. (2023). Effect of virtual reality training on cognitive function and motor performance in older adults with cognitive impairment receiving health care: A randomized controlled trial. *International Journal of Human–Computer Interaction*, pages 1–18.

[17] Li, D., Zhou, J., Yao, K., Liu, S., He, J., Su, J., Qu, Q., Gao, Y., Song, Z., Yiu, C., et al. (2022). Touch iot enabled by wireless self-sensing and haptic-reproducing electronic skin. *Science Advances*, 8(51):eade2450.

[18] Mariakakis, A., Baudin, J., Whitmire, E., Mehta, V., Banks, M. A., Law, A., Mcgrath, L., and Patel, S. N. (2017). Pupilscreen: using smartphones to assess traumatic brain injury. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 1(3):1–27.

[19] Mizerski, R. W. and Dennis White, J. (1986). Understanding and using emotions in advertising. *Journal of Consumer Marketing*, 3(4):57–69.

[20] Modi, N. and Singh, J. (2022). Real-time camera-based eye gaze tracking using convolutional neural network: a case study on social media website. *Virtual Reality*, 26(4):1489–1506.

[21] Nakatani, L. H. and Rohrlich, J. A. (1983). Soft machines: A philosophy of user-computer interface design. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 19–23.

[22] Parizi, F. S. (2022). *Towards Subtle and Continuously Available Input Devices for the Modern Wearable Devices*. University of Washington.

[23] Rafiqi, S. (2015). *Pupilware: Towards cognitive and context-aware framework*. PhD thesis, Southern Methodist University.

[24] Salemi Parizi, F. (2019). *Precise Inside-Out Electromagnetic Input Tracking*. PhD thesis.

[25] Sherman, E., Mathur, A., and Smith, R. B. (1997). Store environment and consumer purchase behavior: mediating role of consumer emotions. *Psychology & Marketing*, 14(4):361–378.

[26] Strbac, V., Pierce, D., Vander Sloten, J., and Famaey, N. (2017). Gpgpu-based explicit finite element computations for applications in biomechanics: the performance of material models, element technologies, and hardware generations. *Computer Methods in Biomechanics and Biomedical Engineering*, 20(16):1643–1657.

[27] Teng, S.-Y., Gupta, A., and Lopes, P. (2024). Haptic permeability: Adding holes to tactile devices improves dexterity. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*.

[28] Wang, T., Zheng, P., Li, S., and Wang, L. (2024). Multimodal human–robot interaction for human-centric smart manufacturing: A survey. *Advanced Intelligent Systems*, 6(3):2300359.

[29] Wang, X., Guo, J., Wu, Y., and Liu, N. (2020). Emotion as signal of product quality: Its effect on purchase decision based on online customer reviews. *Internet Research*, 30(2):463–485.

[30] Wiertlewski, M., Leonardis, D., Meyer, D. J., Peshkin, M. A., and Colgate, J. E. (2014). A high-fidelity surface-haptic device for texture rendering on bare finger. In *International Conference on Human Haptic Sensing and Touch Enabled Computer Applications*, pages 241–248. Springer.

[31] Wigdor, D. and Wixon, D. (2011). *Brave NUI world: designing natural user interfaces for touch and gesture*. Elsevier.

[32] Xu, M., Ng, W. C., Lim, W. Y. B., Kang, J., Xiong, Z., Niyato, D., Yang, Q., Shen, X., and Miao, C. (2022). A full dive into realizing the edge-enabled metaverse: Visions, enabling technologies, and challenges. *IEEE Communications Surveys & Tutorials*, 25(1):656–700.