ChatGPT

Key Topics and Research Areas from the LaTeX Document

The uploaded LaTeX proposal focuses on **contactless physiological monitoring**, specifically the **non-contact prediction of Galvanic Skin Response (GSR)/Electrodermal Activity (EDA)** using **synchronized RGB (visible light) and thermal video**. Major themes include:

- **Remote/Camera-Based Vital Sign Monitoring:** Prior work on measuring heart rate, respiration, etc. via ordinary cameras (remote photoplethysmography, thermal imaging) as a foundation for contactless biosensing.
- **Non-Contact GSR/EDA Measurement:** The novel challenge of estimating sweat-induced skin conductance changes (GSR) without electrodes, e.g. via imaging of sweat gland activity or related facial cues.
- **Stress/Emotion Detection via Physiological Signals:** Using GSR and other autonomic signals (heart rate variability, thermal facial patterns) for detecting stress, anxiety, or emotional arousal in a contact-free manner.
- **Multi-Modal Approaches:** Fusing **thermal infrared** and **RGB video** to improve robustness of contactless measurements (capturing both heat changes from perspiration and color changes from blood flow).
- **Machine Learning for Physiological Signal Prediction:** Developing algorithms (including deep learning) to regress or classify GSR levels from video features, and creating datasets for training such models.

Below is a comprehensive list of **relevant academic articles (2010–2025)** that pertain to these topics. For each work, the title, authors, year, venue, and a link to the publication or abstract are provided:

1. **A Study on the Possibility of Measuring the Non-contact Galvanic Skin Response Based on Near-Infrared Imaging** (2021) — Geumbi Jo; Seunggeon Lee; Eui Chul Lee. *Proceedings of the 12th Int. Conf. on Intelligent Human-Computer Interaction (IHCI 2020)* [1] – SpringerLink Abstract.
 This conference paper is a pioneering work demonstrating that near-infrared camera imaging can capture signals correlated with GSR. It recorded infrared facial videos alongside traditional GSR sensors under stress stimuli, finding measurable correlations. It establishes the feasibility of non-contact GSR estimation by detecting sweat-related facial cues [1] .

2. **SympCam: Remote Optical Measurement of Sympathetic Arousal** (2024) — Björn Braun; Daniel McDuff; Tadas Baltrusaitis; Paul Streli; Max Moebus; Christian Holz. *IEEE EMBS Int. Conf. on Biomedical and Health Informatics (BHI)* (accepted, in press) [2] [3] – arXiv Preprint.
 This recent work introduces "SympCam," a deep learning approach for predicting EDA-based sympathetic arousal from facial videos [3] *. Using a 3D CNN with temporal attention, it improves accuracy of remote EDA prediction (achieving ~0.77 correlation with true GSR) and includes a new dataset of 20 subjects with synchronized face video, EDA and PPG signals* [4] *. It shows that standard rPPG networks alone are not sufficient for GSR, and demonstrates a significant advance in camera-only stress detection (90% accuracy in physical stress classification)* [5] .

3. **Discriminating Stress From Cognitive Load Using Contactless Thermal Imaging Devices** (2021) — Federica Gioia; Maria A. Pascali; Alberto Greco; Sara Colantonio; Enzo P. Scilingo. *43rd*

Annual Int. Conf. of the IEEE Engineering in Medicine and Biology Society (EMBC) [6] – [IEEE Xplore Abstract]().
 This study uses long-wave infrared thermal cameras to distinguish acute stress vs. high cognitive load in 17 subjects [7]*. It simultaneously recorded facial thermal videos and EDA (GSR) signals as ground truth* [8]*. The results showed significant changes in facial temperature (especially in regions like the cheeks) under stress compared to rest, correlating with EDA changes* [9] [10]*. It demonstrates that thermal imaging can serve as a contactless proxy for GSR in stress detection, laying groundwork for non-contact stress monitoring.*

4. **Towards a Contactless Stress Classification Using Thermal Imaging** (2022) — Federica Gioia; Alberto Greco; Alejandro L. Callara; Enzo P. Scilingo. *Sensors* **22**(3): 976 [11] [12] – [MDPI Open-Access]().
 An extended journal study building on thermal imaging for stress recognition. It collected thermal face videos along with electrodermal, cardiac, and respiratory signals from 25 subjects during a Stroop-test stressor [13]*. Using machine learning (SVM with recursive feature elimination), the authors show that combining thermal features with traditional autonomic signals yields ~97% stress classification accuracy, and even thermal-only features can achieve ~87% accuracy in detecting stress contactlessly* [12] [14]*. This work highlights the efficacy of infrared facial temperature analysis as a non-invasive tool for stress/arousal monitoring.*

5. **Emotional State Detection on Mobility Vehicle Using Camera: Feasibility and Evaluation Study** (2021) — Tafsut Tagnithammou; Éric Monacelli; Antoine Ferszterowski; Lambert Trénoras. *Biomedical Signal Processing and Control* **66**: 102419 [15] – [ScienceDirect Abstract]().
 This work evaluates using a low-cost RGB camera to detect drivers' emotional states (stress vs. relaxation) on a two-wheel mobility device [16]*. It uses remote photoplethysmography (rPPG) to extract heart rate variability (HRV) metrics from facial videos as indicators of stress* [16] [17]*. The authors validated the camera-based HRV against contact sensors and achieved successful stress classification (improved with boosting and SVM classifiers) even in a quasi-dynamic scenario* [16]*. It confirms the feasibility of camera-only stress detection in a mobile context, relevant as a proof-of-concept for contactless GSR since HRV is another autonomic signal related to arousal.*

6. **Galvanic Skin Response and Photoplethysmography for Stress Recognition Using Machine Learning and Wearable Sensors** (2024) — Alina Nechyporenko; Marcus Frohme; Yaroslav Strelchuk; Vladyslav Omelchenko; Vitaliy Gargin; Liudmyla Ishchenko; Victoriia Alekseeva. *Applied Sciences* **14**(24): 11997 [18] – [MDPI Open-Access]().
 Although this study uses wearable sensors (finger GSR and ear PPG) rather than cameras, it is relevant for illustrating state-of-the-art in GSR-based stress detection. Using a realistic "air raid siren" stressor on 37 participants, it extracted numerous features from GSR and heart-rate (PPG) signals and applied machine learning (k-NN, SVM, etc.) for binary stress classification [19] [20]*. The best model (k-NN) achieved ~83.3% accuracy in distinguishing stress vs. no-stress using a combination of heart rate variability features and GSR features* [20]*. This work underscores the complementary roles of GSR and PPG in stress recognition, providing context for why a multi-modal (thermal + RGB) camera approach could emulate these signals remotely.*

7. **Anxiety Detection System Based on Galvanic Skin Response Signals** (2024) — Abeer Al-Nafjan; Mashael Aldayel. *Applied Sciences* **14**(23): 10788 [21] [22] – [MDPI Open-Access]().
 This paper focuses on machine-learning classification of anxiety using GSR data. While it uses a benchmark contact GSR dataset rather than video, it is relevant to the application domain of the proposal (mental health monitoring via GSR). The authors evaluate three algorithms (SVM, k-NN, Random Forest) and also propose an autoencoder-based feature extraction for GSR signals [23] [24]*. They report high accuracy (~98% with k-NN) in distinguishing anxious vs. non-anxious states using GSR features* [25]*. This demonstrates the potential of GSR as a reliable indicator of anxiety/stress, motivating efforts to*

capture GSR without contact. It provides insight into which signal features and classifiers might be useful for a contactless GSR system.

8. **Challenges and Prospects of Visual Contactless Physiological Monitoring in Clinical Study** (2023) — Bin Huang; Shen Hu; Zimeng Liu; Chun-Liang Lin; Junfeng Su; Changchen Zhao; Li Wang; Wenjin Wang. *npj Digital Medicine* **6**(1): 231 [26] – [Nature (Open Access)]().
 A recent review article that surveys the state-of-the-art in camera-based vital sign monitoring and discusses its translation to clinical settings. It covers remote photoplethysmography for vital signs and notes the gap that electrodermal activity lacks a mature contactless solution (highlighting it as an open challenge). The paper identifies technical hurdles such as illumination variability, skin tone differences, motion artifacts, and privacy issues in Visual Contactless Physiological Monitoring (VCPM) [27] [28] *. It provides a high-level perspective on where contactless GSR fits into the broader landscape, and why a multimodal approach (like combining thermal and RGB imaging) could be promising for addressing some challenges (e.g., all-light-condition monitoring, as suggested in their outlook).*

9. **Deep Learning and Remote Photoplethysmography Powered Advancements in Contactless Physiological Measurement** (2024) — Wei Chen; Zhe Yi; Lincoln J.R. Lim; Rebecca Q.R. Lim; Aijie Zhang; Zhen Qian; Jiaxing Huang; Jia He; Bo Liu. *Frontiers in Bioengineering and Biotechnology* **12**: 1420100 [29] – [Frontiers (Open Access)]().
 This is an extensive review of computer-vision-based vital sign monitoring with emphasis on deep learning and remote PPG. It covers recent algorithms for contactless measurement of heart rate, respiratory rate, blood oxygen, blood pressure, heart rate variability, etc., and discusses how deep learning is improving robustness in real-world settings [30] [31] *. While GSR is not yet a standard part of such reviews, the paper's discussion of "lack of uniformity or standardization" in contactless methods and the push for multi-signal fusion is directly relevant* [32] [33] *. It underscores the need for integrating multiple modalities (the approach taken in the LaTeX proposal) to capture a more complete picture of autonomic activity. This article thus provides a cutting-edge context for the technical methodologies (e.g., CNNs, signal processing) relevant to contactless GSR prediction.*

10. **A Non-Contact Technique for Measuring Eccrine Sweat Gland Activity Using Passive Thermal Imaging** (2014) — Alan T. Krzywicki; Gary G. Berntson; Barbara L. O'Kane. *International Journal of Psychophysiology* **94**(1): 25–34 [34] – [ScienceDirect Abstract]().
 This study (from a psychophysiology perspective) demonstrates a direct method to image sweat gland activation via thermal cameras. High-resolution mid-wave infrared (3–5μm) imaging was used to visualize sweat pores on fingertips and faces while subjects performed breathing tasks [35] *. They defined metrics like Pore Activation Index (PAI) – essentially counting active sweat pores – and found that thermal-imaged pore activity on fingertips correlates with simultaneous skin conductance responses from a GSR device* [36] *. Facial sweat responses were also observed. This is a key proof-of-concept that thermal imaging can pick up perspiration dynamics related to GSR* [37] *. It provides foundational evidence supporting the LaTeX proposal's idea that sweat-induced thermal changes in the face can be quantified and related to electrodermal arousal.*

11. **Advancements in Noncontact, Multiparameter Physiological Measurements Using a Webcam** (2011) — Ming-Zher Poh; Daniel J. McDuff; Rosalind W. Picard. *IEEE Transactions on Biomedical Engineering* **58**(1): 7–11 [38] – [IEEE Xplore]().
 A seminal paper that introduced webcam-based vital sign monitoring, helping launch the field of remote physiological sensing. Poh et al. *developed a method using a simple webcam and independent component analysis (ICA) on facial video to extract the blood volume pulse (BVP) from tiny skin color changes* [39] *. They validated heart rate, respiratory rate, and heart rate variability measurements against medical sensors, finding high agreement* [39] *. This work didn't address GSR, but it established that contactless video can reliably capture cardiovascular signals related to autonomic activity, which is a cornerstone for subsequent*

efforts (like the current proposal) to extend such techniques to GSR. It also introduced techniques (like ICA, motion tolerance strategies) that are widely cited in later research on remote PPG and could inspire methodology for remote EDA measurement.

12. **Continuous Monitoring of Vital Signs Using Cameras: A Systematic Review** (2022) — Vinothini Selvaraju; Nicolai Spicher; Ju Wang; Nagarajan Ganapathy; Joana M. Warnecke; Steffen Leonhardt; Ramakrishnan Swaminathan; Thomas M. Deserno. *Sensors* **22**(11): 4097 [40] – MDPI Open-Access.
 This systematic review covers over 100 studies (2010–2021) on camera-based vital sign monitoring (heart rate, respiration, oxygen saturation, etc.), synthesizing the technical approaches and performance reported in the literature. It highlights common challenges (motion artifacts, lighting, skin tone, etc.) and strategies like multi-camera setups and sensor fusion [41] [42]. *While GSR is notably* absent *in the vital signs reviewed (underscoring the research gap), the paper's conclusions strongly support the use of multi-modal imaging (RGB + NIR) and advanced algorithms to improve robustness* [41] [43]. *The review provides a broad validation that visual monitoring of physiology is feasible and improving, reinforcing the plausibility and timeliness of extending it to GSR measurement.*

13. **Towards a Contactless Measurement of Electrodermal Activity in Psychophysiological Experiments** (2025 – *anticipated*) — *[No widely recognized publication as of 2024]*.
 *(*Note: *The absence of a specific entry here highlights that, aside from the Jo* et al. *(2021) study above and very recent efforts like SympCam, the field still lacks extensive literature on contactless EDA measurement**. The proposed research aims to fill this gap, building on the foundational works and multidisciplinary insights listed above.)

Each of the above publications is **highly relevant** to the LaTeX document's themes, either by directly tackling contactless GSR estimation or by providing crucial background in contactless vitals sensing and GSR-based emotion/stress analysis. Together, they chart the evolution of this research area over the past 15 years and underscore the novelty and importance of the proposed work. Each reference can be accessed via the provided links for more details and full texts or abstracts on the publisher's site.

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