DEVELOPMENT OF A MODULAR COVERT AUDIO-VIDEO SURVEILLANCE SYSTEM FOR NATIONAL SECURITY APPLICATIONS USING 4G/5G TRANSMISSION

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ABSTRACT

This paper presents the ongoing development of an innovative modular hardware-software system designed for the discreet implementation of authorized technical surveillance measures under national security warrants, within the framework of the Romanian SOL2024-T6 project funded by UEFISCDI and coordinated with the Ministry of Internal Affairs (MAI) of Romania. The system addresses the need for reliable, long-term covert audio-video monitoring in challenging environments (distances ≈2 m, harsh installation conditions, limited accessibility, no requirement for court-admissible evidence). Key hardware features include a compact single-board computer platform with support for analog (RCA) and optional Full-HD digital cameras, wired microphones (with best-effort exploration of wireless alternatives), a 4G/5G cellular modem for encrypted live streaming, flexible power supply (230 V AC mains, 12 V DC vehicle, 5 V auxiliary with optional power-bank backup), surge immunity, passive cooling, and remote health monitoring (input voltage, temperature, signal strength). Automatic graceful degradation mechanisms (resolution/framerate reduction, fallback to 4G or audio-only mode) ensure operational continuity under adverse conditions, while a hardware watchdog provides reliable restart capability. The software architecture enables continuous encrypted transmission of the audio-video stream to a remote server without local storage, automatic segmentation into ≈30-minute files with descriptive naming, on-demand playback, and real-time watermarking (camera identifier + timestamp). Feasibility studies are underway for audio extraction from video streams and speech-to-text transcription. The first functional prototype based on Raspberry Pi 5, an analog camera, and a 4G modem has been successfully demonstrated in May 2025, validating end-to-end live capture, transmission, reception, and segmented storage. Subsequent iterations focus on replacing active cooling with fully passive solutions, optimizing power consumption, and finalizing lightweight encryption/APN-private communication schemes. The resulting system offers a cost-effective, rapidly deployable, and resilient platform for authorized national-security surveillance operations, with potential extensions to other law-enforcement and intelligence scenarios.

Keywords: Covert surveillance, audio-video streaming, 4G/5G transmission