Research on Intelligent Detection Methods for Underwater Defect Imaging of Dams

Under the effects of long-term scouring and material aging, dams inevitably develop defects such as cracks and spalling. Underwater robots equipped with imaging devices have become the primary means for dam defect detection, and at the core of this approach lies a continuously evolving set of intelligent detection methods: from early traditional image-processing methods that rely on hand-crafted features, to deep learning-based intelligent detection, and to the recently emerging large-model paradigm. Following this evolutionary path, this report first reviews the development of artificial intelligence techniques in underwater dam defect detection. It then focuses on a series of works carried out by our team along this same path. To support this research, the team built UDCD, a real-world underwater dam crack dataset, and has continually explored new methods and techniques to improve detection performance: early on, traditional methods such as clustering were used for automatic crack detection and extraction; subsequently, techniques such as adversarial transfer learning markedly improved detection accuracy and speed; a CNN-Transformer hybrid architecture (Crack-ConvT Net) was then proposed to strengthen long-range dependency modeling in complex backgrounds; and the team continues to explore the application of large-model techniques. Building on this, the team has further extended the dataset to five defect types: cracks, spalling, exposed rebar, bugholes, and erosion, advancing toward unified multi-defect detection. Finally, oriented toward frontier directions such as large vision models and few-shot learning, the report looks ahead to the future of intelligent underwater dam inspection, aiming to promote the deep integration of advanced signal processing and artificial intelligence technologies into the practical operation and maintenance of hydraulic engineering.