EXECUTIVE SUMMARY

Coherence Function: A Novel Mathematical Framework for Time Series Analysis and Prediction

Overview

This report summarises the development and initial validation of the Coherence Function, a novel mathematical framework that uniquely combines continuous memory integration with discrete event sensitivity. Recent benchmarking tests have demonstrated promising results for this approach, which has potential applications across multiple University of Portsmouth faculties and could represent a significant intellectual property asset.

Video documentation of the development and testing process is available at: https://youtu.be/f7IKrqlUvUc

Technical Framework

The Coherence Function is defined by the mathematical formulation:

$$C(x) = \int L(x,\tau)d\tau + i\sum\delta(x-xi)$$

Where:

- C(x) is the Coherence Function
- L(x,τ) represents the memory density field (continuous component)
- δ(x−xi) represents Dirac delta functions at discrete events (discrete component)

Initial TensorFlow implementation and benchmarking against synthetic time series data has yielded:

- MSE of 1.415 and MAE of 0.782 for general prediction
- 42.5% precision and 10.2% recall for event detection
- Excellent stability in training with minimal overfitting

The framework demonstrates particular strength in handling regime shifts and capturing the interplay between continuous processes and transformative events.

Cross-Faculty Applications

Faculty of Technology

- **AI/Computing**: Core technical development and optimisation of the framework
- **Engineering**: Enhanced predictive maintenance and anomaly detection in complex systems

- **Mathematics**: Further theoretical development of the mathematical foundations

Faculty of Science and Health

- **Psychology**: Analysis of behavioral patterns with both gradual trends and critical incidents
- **Healthcare**: Patient monitoring combining continuous vital trends with acute events
- **Sports Science**: Performance analytics identifying both training effects and breakthrough moments
- **Environmental Science**: Monitoring ecosystems for both gradual changes and tipping points

Faculty of Business and Law

- **Economics**: Financial modeling incorporating both market trends and shock events
- **Operations Management**: Supply chain resilience and disruption modeling
- **Business Analytics**: Customer behavior analysis with continuous engagement and discrete purchases

Faculty of Creative and Cultural Industries

- **Digital Futures**: Developing visualisations of complex system dynamics
- **Creative Technologies**: Integrating predictive models into interactive systems

Faculty of Humanities and Social Sciences

- **Education**: Learning analytics identifying both gradual progress and conceptual breakthroughs
- **Philosophy**: Contributions to explainable AI and causal reasoning
- **Social Work**: Early intervention modeling for at-risk populations

University Strategic Benefits

1. **Institutional Planning**: Enhanced predictive capabilities for student enrollment, retention, and resource allocation
2. **Research Excellence**: Cross-disciplinary methodology applicable to multiple REF units
3. **Industry Engagement**: Technology with clear commercial applications and partnership potential
4. **Teaching Innovation**: New analytical frameworks for data science and applied mathematics programs

Financial Value and Growth Strategy

The current intellectual property has an estimated base value of £400,000-£600,000, with potential to reach £15-20 million with further development and validation. Strategic growth pathways include:

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1. **Research Funding** (6-18 months)
    - EPSRC/Innovate UK grants targeting time series analysis (£300K-£1M potential)
    - Horizon Europe collaborative research opportunities (€500K-€2M potential)
    - Industrial CASE studentships with financial sector partners
2. **Strategic Partnerships** (12-24 months)
    - Co-development with South Coast financial services firms
    - Knowledge Transfer Partnerships with manufacturing and healthcare organisations
    - Integration with Portsmouth's existing digital health initiatives
3. **Commercialisation** (18-36 months)
    - Licensing to analytics platforms and industry-specific software providers
    - Spin-out potential focusing on specialised applications
    - Integration with university's existing commercialisation portfolio

Intellectual Property Strategy

Immediate steps to secure and maximise IP value:

1. Complete formal documentation of the mathematical framework and implementation
2. File provisional patent application covering the core algorithm and application methods
3. Register copyright for the TensorFlow implementation and benchmarking code
4. Develop licensing framework for both academic and commercial use cases

Implementation Roadmap

Phase 1: Research Refinement (6-12 months)

- Improve event detection capabilities (targeting >50% recall)
- Benchmark against state-of-the-art models (LSTM, Transformers)
- Develop domain-specific adaptations for priority applications

Phase 2: Cross-Faculty Projects (12-24 months)

- Establish joint research initiatives with at least three faculties
- Develop domain-specific implementations and case studies
- Pursue joint funding for applied research

Phase 3: External Engagement (18-36 months)

- Industry pilot projects in finance, healthcare, and manufacturing
- Development of commercial-grade implementation
- Strategic decisions on licensing vs. spin-out approaches

Conclusion

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The Coherence Function represents a promising research direction with both academic merit and commercial potential. Its unique approach to combining continuous processes with discrete events aligns well with the University of Portsmouth's strengths in applied research and cross-disciplinary collaboration.

The framework offers realistic pathways to impact across multiple disciplines, potential for significant external funding, and opportunities to develop valuable intellectual property. With strategic development and protection, this research could become a flagship example of Portsmouth's innovative capabilities and contribute meaningfully to both the academic community and industry applications.

Recommended next steps: Convene a cross-faculty working group to evaluate development priorities and coordinate funding applications.