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Thesis Title: **ENHANCED SPATIO-TEMPORAL RELATIONAL PROBABILITY TREES AND FORESTS**

ABSTRACT:
Many real world domains, such as severe weather events, are inherently spatiotemporal in nature. Each year severe weather induced by thunderstorms causes property damage, injury, and loss of life. Convectively induced turbulence produced by thunder storms is a hazard to airlines which at best requires rerouting flight paths, but can lead to significant delays and even structural damage to the aircraft and loss of life. Tornados are possibly the most impressive and destructive potential product of thunderstorms. This thesis introduces a considerably augmented Spatiotemporal Relational Probability Tree (SRPT), a decision-tree type model for spatiotemporal relational data, and applies it to multiple severe weather domains. The goal of this new SRPT is to significantly enhance the predictive capabilities for such events through an improved understanding of their formation.

Domains such as severe weather require a system that is capable of representing and reasoning about complex spatiotemporal data. The dynamics of attributes and relationships varying both spatially and temporally provides a unique set of challenges. SRPTs are a form of decisions trees capable of reasoning about complex spatiotemporal relational data. SRPTs reason with high level objects and their relationships which are extracted from the raw low level dataset. This allows the SRPTs to reason in more abstract terms and to use relationships which are critical to understanding how things interact.

This thesis introduces significant enhancements to SRPT which increases their ability to reason about spatiotemporal data. Some high-level objects come from real-valued two- or three-dimensional temporal regions called fields. Instead of discarding these fields we add the ability to ask question about the gradient, divergence, and curl of those fields. And we add the ability to recognize the shape of fields allowing for questions regarding change of shape and orientation. Also, we add the mechanism to reference a single object within the data, and simple boolean operations on two base distinctions. These additions are validated on a several real world domains with the primary focus of classifying storms as tornado producing.

The SRRF algorithm learned robust classifiers on each of the domains, either outperforming the SRRF without fields or performing equally well. Analysis of the forests produced showed that features the SRRF algorithm used were consistent with meteorological theories. We have shown that the addition of fields can be a valuable resource to the SRRF algorithm for spatiotemporal analysis.