**Motivation**

- **Limitations of Precise Reasoning**
  - Concepts without well-defined boundaries often have to be defined with 'artificial' boundaries
  - Originally uncertain relationships have to be forced into precise relationships for knowledge representation
  - Distorting reality and expert thinking
  - Giving up important properties
  - Loss of authentic representation

- **Uncertainty Reasoning**
  - Uncertainty is an intrinsic feature of real-world knowledge
  - Based on known uncertain facts (evidence)
  - Applying uncertain axioms and rules
  - Resulting in conclusions that are uncertain to some degree
  - Better resembling human reasoning in its use of approximate information and uncertainty to generate decisions

**Description Logics and OWL**

- **Description Logics**: Logic-based knowledge representation formalisms about the conceptual knowledge of arbitrary domains
  - DLs basics include concepts, roles, individuals, constructors, axioms and assertions
- **OWL: Web Ontology Language**
  - W3C's OWL 1 & 2 recommendations for the Semantic Web
  - Based on Description Logics
  - Three OWL 1 species: OWL Lite, OWL DL, and OWL Full
  - Three OWL 2 profiles: OWL 2 EL, OWL 2 QL, and OWL 2 RL

**Fuzzy Logic and Vague Sets**

- **Fuzzy Logic**: Membership function $u(x)$ with single value ($D \rightarrow [0,1]$)
  - No accuracy measurement
- **Vague Sets**: Interval-valued
  - $[u(x), 1-u(x)]$
  - Truth-membership function: $u_t(x)$
  - False-membership function: $u_f(x)$
  - Positive and negative evidence
  - Accuracy measurement

**Solution**

- **Fuzzy Description Logic fALCHIN**
  - A fuzzy extension to the Description Logic ALCHIN
  - Based on Vague Sets
  - fALCHIN includes fuzzy concepts, roles, and constructors
- **Fuzzy Knowledge Base**
  - Fuzzy axioms and fuzzy assertions
- **Core Reasoning Algorithm**
  - Based on tableau algorithm with fuzzy extension
- **Various Inference Services and Procedures**
  - F-OWL (Fuzzy OWL)
  - A fuzzy extension to OWL 1 & 2
  - Abstract concrete syntax / functional-style syntax
  - Core semantics based on fALCHIN
- **Prototype Implemented in Prolog: fALCAS**

**System Architecture**

**Application Services**

- **Medical Application Scenarios**
  - Consistency Checking (general)
  - Fuzzy Instance Entailment (patient eligibility)
  - Instance role entailment
  - Instance concept entailment
  - Fuzzy Concept Subsumption and Similarity (symptom and diagnosis comparison)
  - Fuzzy Retrieval (patient documents)
  - Top-k instances retrieval
  - Threshold-$\theta$ instances retrieval