Inference with resolution



- We put each first-order sentence into conjunctive normal form
 - We remove quantifiers
 - We make each sentence a disjunction of literals (each literal is universally quantified)
- We show KB $^{(-\alpha)}$ is unsatisfiable by deriving the empty clause
 - Resolution inference rule is our method
 - Keep resolving until the empty clause is reached

Resolution



Look for matching sentences

- Shared literal with opposite sign
 - Substitution may be required
- [Animal (F(x)) V Loves (G(x), x)] and
 [~Loves (u,v) V ~Kills (u, v)]
 - F(x) = animal unloved by x
 - G(x) = someone who loves x

Resolution



What does this mean in English?

- [Animal (F(x)) V Loves (G(x), x)]
 - -F(x) = animal unloved by x
 - G(x) = someone who loves x
- [~Loves (u,v) V ~Kills (u, v)]

- For all people, either a person doesn't love an animal or someone loves the person
- Nobody loves anybody or nobody kills anybody

Resolution



- [Animal (F(x)) V Loves (G(x), x)] and
 [~Loves (u,v) V ~Kills (u, v)]
 - Loves and ~Loves cancel with substitution
 - u/G(x) and v/x

- Resolvent clause
 - [Animal (F(x)) v ~Kills (G(x), x)]

Knowledge Base Example



 $\begin{array}{ll} \neg American(x) \lor \neg Weapon(y) \lor \neg Sells(x,y,z) \lor \neg Hostile(z) \lor Criminal(x) \\ \neg Missile(x) \lor \neg Owns(Nono,x) \lor Sells(West,x,Nono) \\ \neg Enemy(x,America) \lor Hostile(x) \\ \neg Missile(x) \lor Weapon(x) \\ Owns(Nono,M_1) \\ Missile(M_1) \\ American(West) \\ Enemy(Nono,America) \\ \end{array}$

Resolution example



