Explanation Based Learning (EBL)

What is EBL ?

- Learning *general* problem-solving techniques by observing and analyzing human solutions to *specific* problems.
- EBL attempts to formulate a *generalization* after observing only a single example.
- Introduced by Gerald De Jong in 1981.

"Hey! Look what Zog do!"

(drawn by Gary Larson)

The EBL Hypothesis

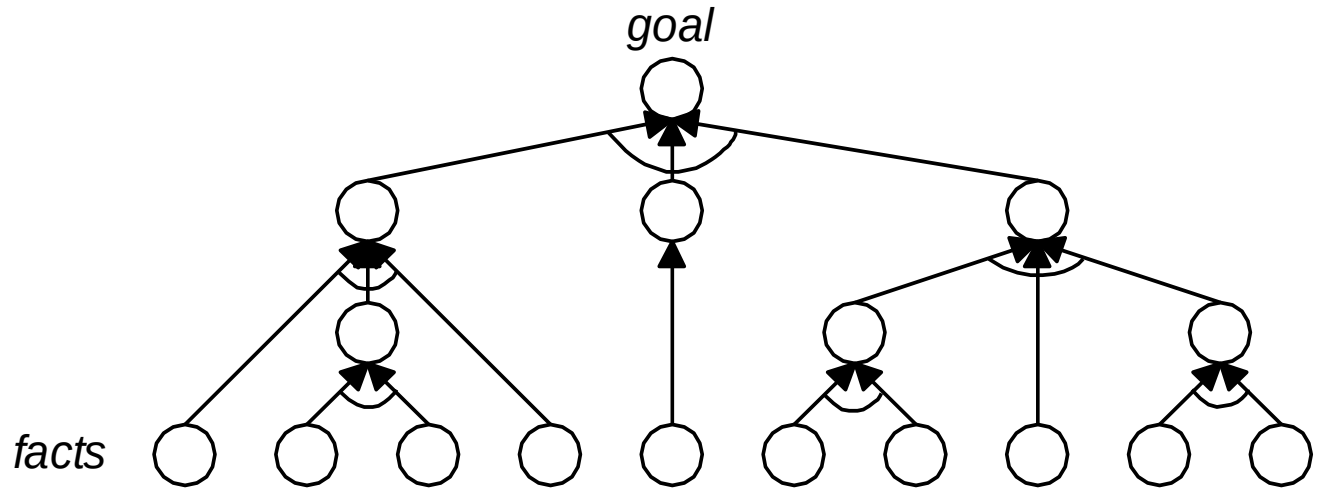
- EBL is based on the hypothesis that an intelligent system can learn a general concept after observing only a single example.
- By understanding why an example is a member of a concept, can learn the essential properties of the concept.
- EBL uses prior knowledge to analyze or explain each training example in order to infer what properties are relevant to the target function and which are irrelevant.

Learning by Generalizing Explanations

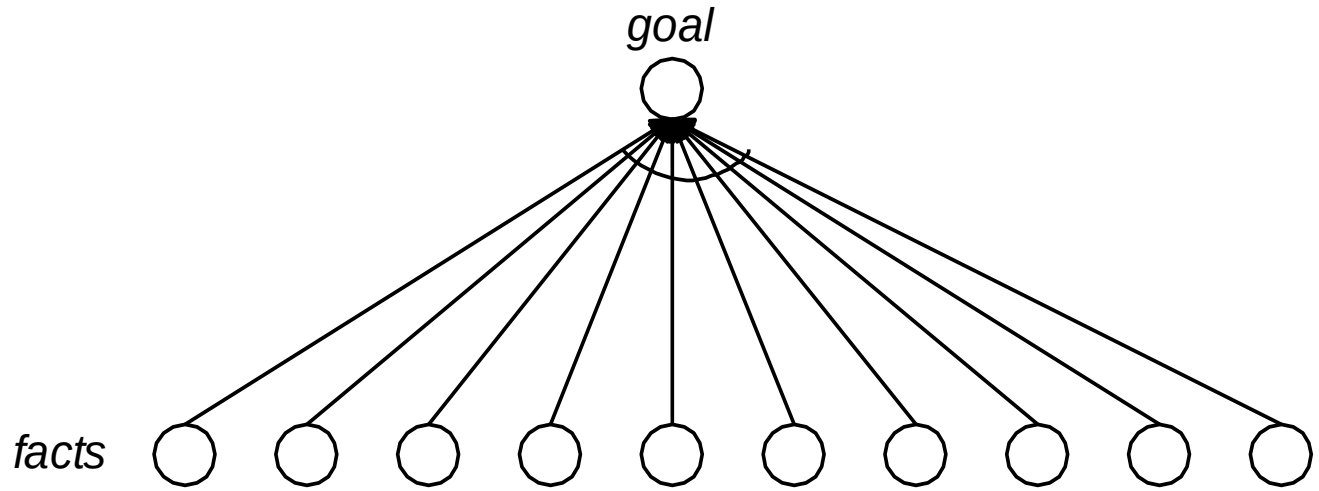
- Given
  - Goal concept (e.g., some predicate calculus statement)
  - Training example (facts)
  - Domain Theory (inference rules)
  - Operationality Criterion
- Given this four inputs, the task is to determine a generalization of the *training example* that is sufficient concept definition for the *goal concept* and that satisfies the *operationality criteria*.
- The operationality criterion requires that the final concept definition be described in terms of the predicates used to describe the training example.

Standard Approach to EBL

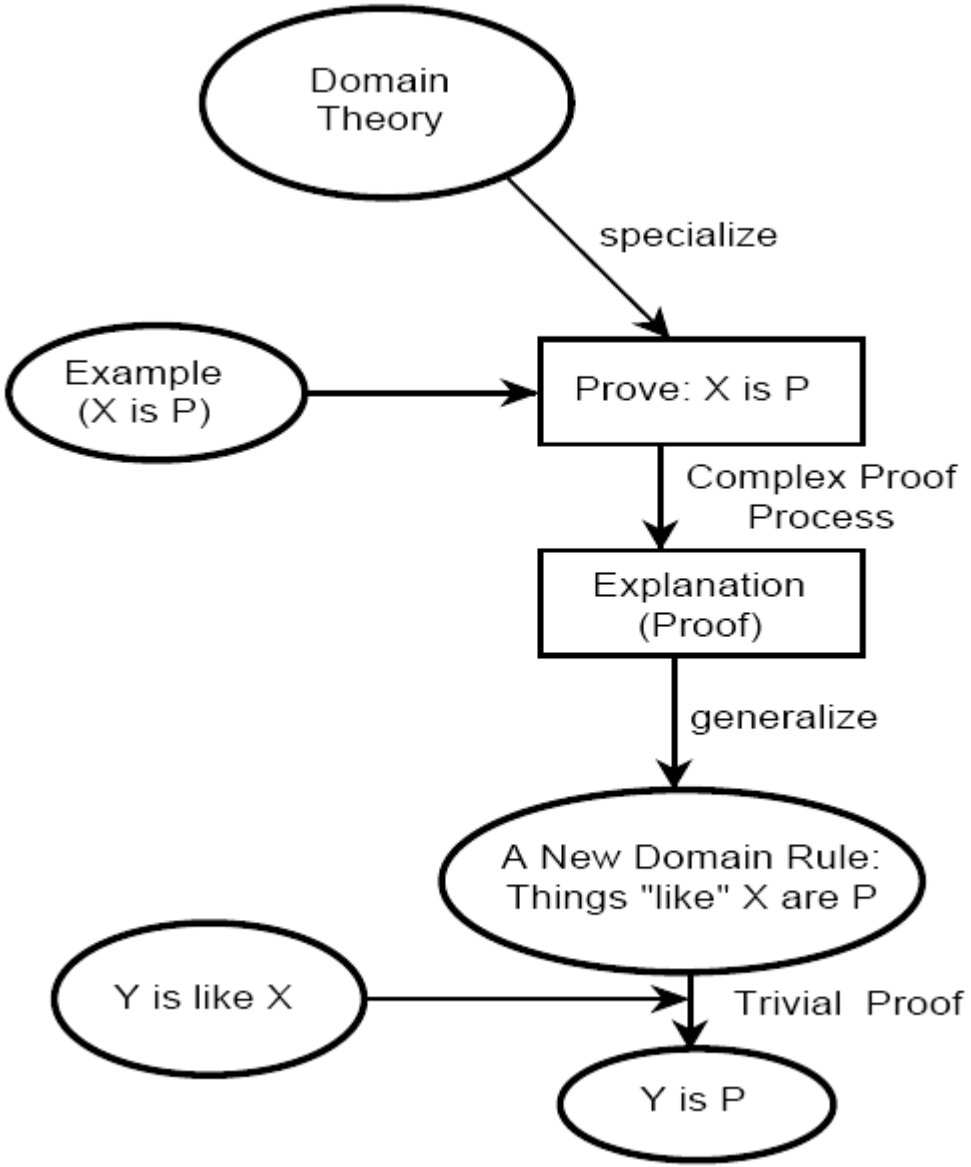
An Explanation (detailed proof of goal)



After Learning (go directly from facts to solution):



The EBL Process



An Example

- Domain theory:

  Fixes(u,u) ➔ Robust(u) // An individual that can fix itself is robust

  Sees(x,y) Λ Habile(x) ➔Fixes(x,y) // A habil individual that can see another entity can // fix that entity

  Robot(w) ➔Sees(w,w) // All robots can see themselves

  R2D2(x) ➔ Habile(x) // R2D2-class in individuals are habil

  … … …

- Facts:

  Robot(Num5)

  R2D2(Num5)

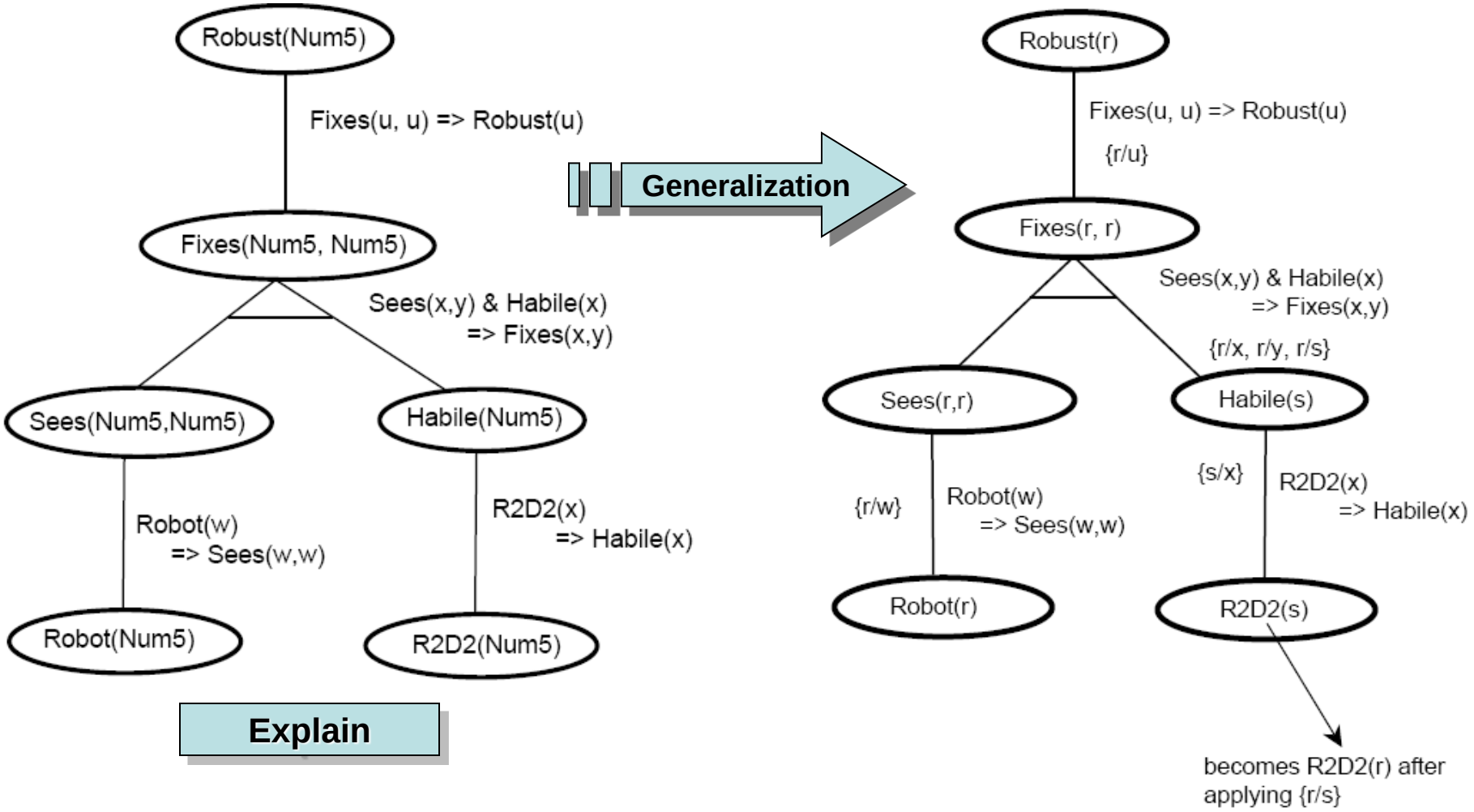
  Age(Num5,5)

  … … …

- Goal:

  Robust(Num5)

An Example (continued…)



Robot(r) ∧ R2D2(r) ➔Robust(r)

History ??

- EBL may be viewed as a convergence of several distinct lines of research within machine learning.
- EBL has developed out of efforts to address each of the following problems:
  - Justified generalization.
  - Chunking.
  - Operationalization.
  - Justified analogy.

Recommended Reading

- Mitchell T.M., Keller R.M., Kedar-Cabelli S.T., Explanation-Based Generalization: A Unifying View, *Machine Learning* 1, pp. 47-80, 1986, Kluwer Academic Publishing.
- DeJong G., Mooney R., Explanation-Based Learning: An Alternative View, *Machine Learning* 1, 1986, Kluwer Academic Publishing.
- Ellman, T, Explanation-Based Learning: A Survey of Programs and Perspectives, ACM Computing Survayeys, Vol. 21, No. 2, 1989.

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Conclusions

- **Explanation Based Learning (EBL):**
  - **Needs only one example.**
  - **Requires complete knowledge about the concept.**
  - **Shows the importance of prior knowledge in learning.**