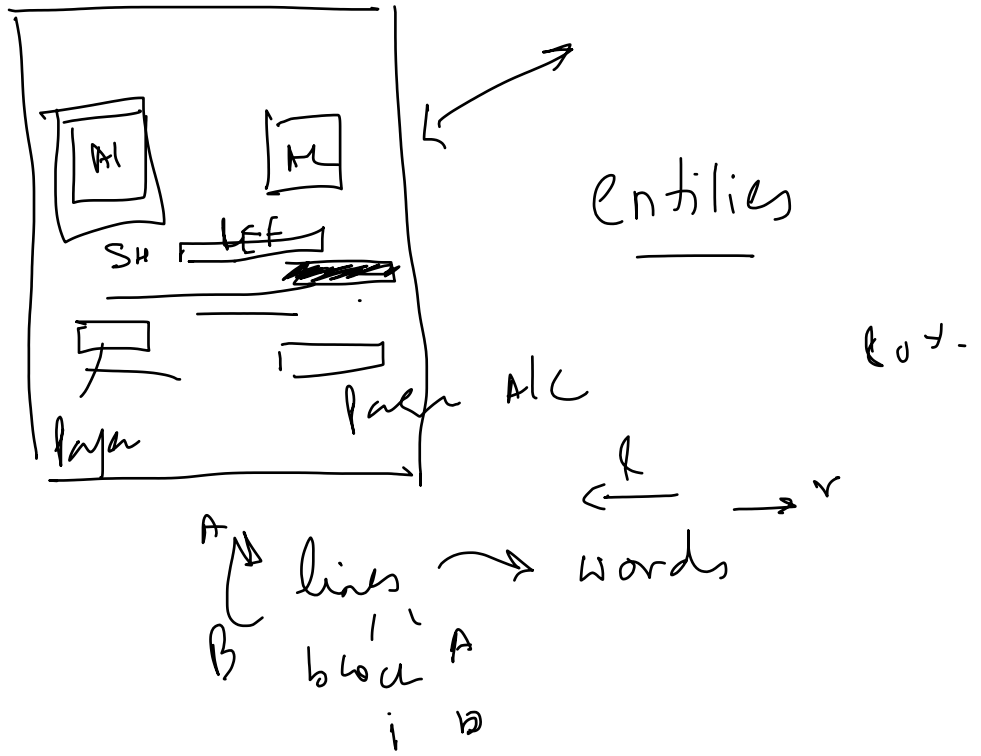
3. Learning from almost No Data:
Meta-interpretive Program Synthesis



Learning from One Example using Logical Induction

Reference - *One-shot Information Extraction from Document Images using Neuro-Deductive Program Synthesis*

Learn a *program* to extract specific entities from document images that follow a template, from *one* sample. E.g. correspondence no., 186FDBC1802472 here:

```
TO
DNB NOR BANK ASA
TRADE FINANCE/GUARANTEE
DEPT. NO.0021
OSLO NORWAY
NO

Please Quote in all correspondence
186FDBC1802472
```

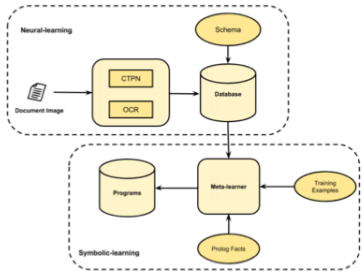
DL to extract to a database; then ILP.

A correct program for this example:

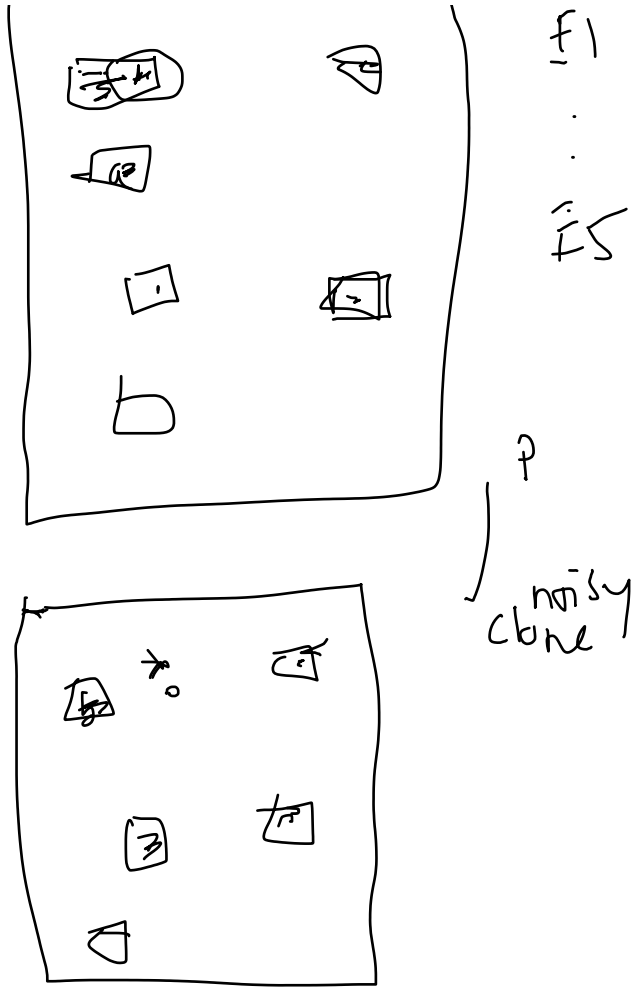
```
corr(A,B) :-
        has_keyword('Please', A,C),
        has_line_below(C,B).
```

But ILP will also find this incorrect one:

```
corr(A,B) :-
       has_keyword('Please',A,C),
       left_of('Please',C,D),
       right_of('ASA',D,C),
       has_line_below_word(C,B).
```



Key idea: perturb *all* entities in the DB to create a 'noisy clone' and feed both examples to ILP, which then learns the correct program.

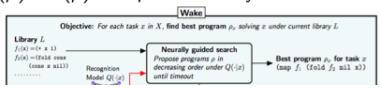


Logical Meta-learning

Reference - *DreamCoder: Growing generalizable, interpretable knowledge with wake-sleep Bayesian program learning*

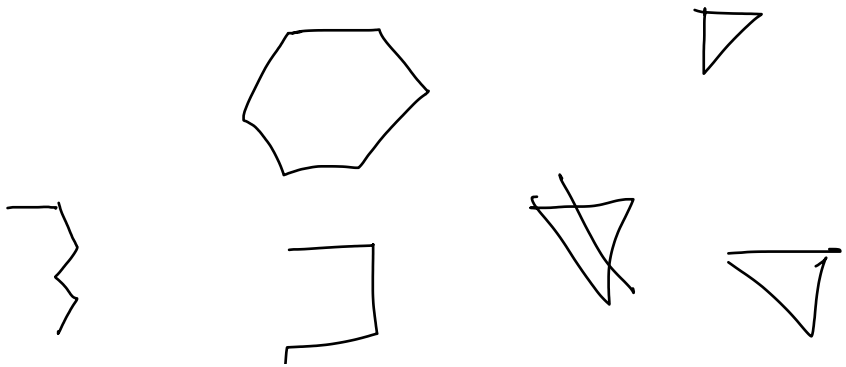
For input-output task x learn a program ρ_x using library of primitive operations L.

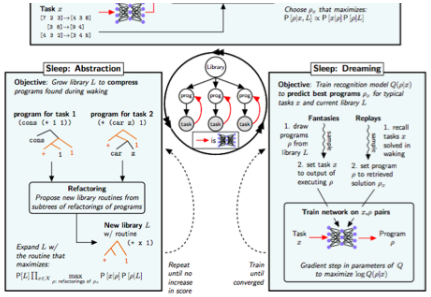
$P(\rho) \sim l(\rho)$. 'Improve' library and learn faster as more tasks are solved.



Wake:

$\rho_x^* = \text{argmax}_\rho P(\rho|x, L) \propto$





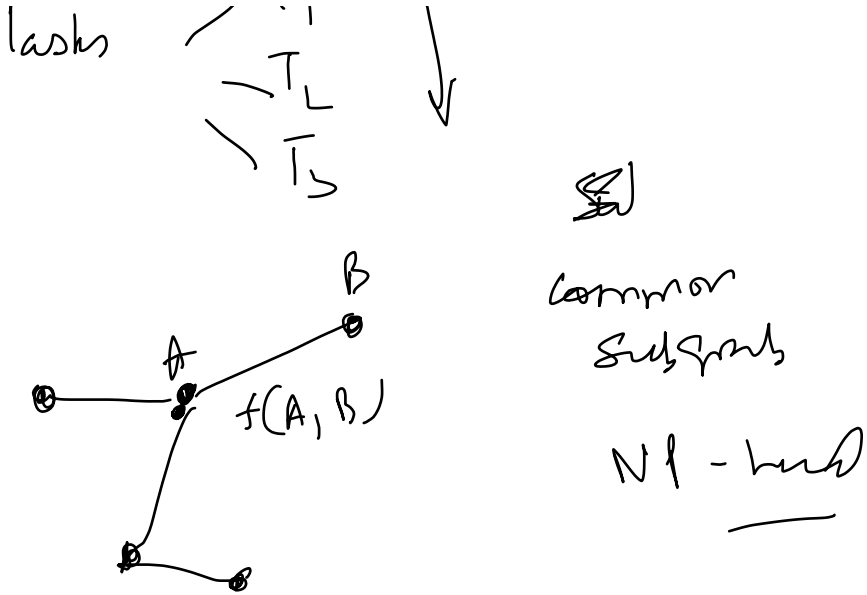
$P(x|\rho)P(\rho|L)$ for task x.

Sleep: $L = \operatorname{argmax}_L \prod_x \max_{\rho=r(\rho_x)} P(x|\rho)P(\rho|L)$

Dream: update $Q_\theta(\rho|x)$: $\operatorname{argmin}_\theta \|P(\rho|x,L) - Q_\theta(\rho|x)\|$

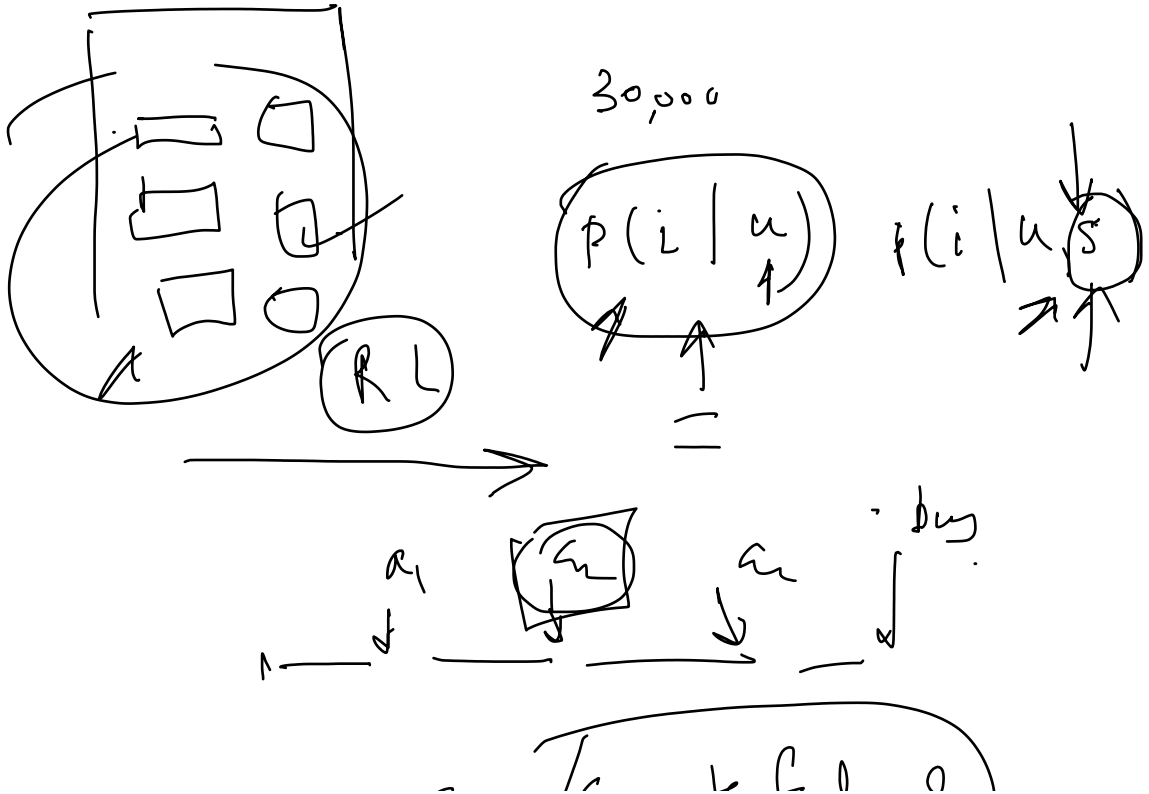
Key: efficient algorithm to search over (potentially exponential) refactorings $r(\rho_x)$.

4. Applications of Meta-learning



Selected Applications of Meta-learning

1. **E-commerce and Retail:** Recommendations systems as user-behavior changes, new items are introduced. Adapting to local users/items. Demand forecasting as user-behavior and economic indicators change; adapting to local conditions/products.
2. **Advertising:** Multi-channel attribution models that adapt to new inventory and content. Maximizing cost-per-conversion.
3. **Manufacturing Supply-chain:** Demand forecasting, optimal replenishment, pre-picking in distribution centers across *very* large number of SKUs.
4. **Industrial Operations (IOT):** Optimal control of industrial equipment, plant operations; preventive maintenance (predicting RUL, detect anomalies). Adapting to equipment from different manufacturers, conditions, usage profiles etc.



Applications of Meta-learning (cont)

5. **Healthcare:** Drug/protocol efficacy and optimal choice, from operational data (causality). Predicting incidents in ICU. Medical imaging. Adapting to different populations, equipment, etc.
6. **Finance:** Optimizing returns while controlling risk, adapting to changes in market conditions. Adapting global models to specific financial instruments.
7. **Software Development:** Program synthesis from examples, natural language. Adaptation to different use-cases, programming/natural languages.
8. **Cybersecurity:** Detecting malware/intrusions. Adapting to new attacks - most attacks are variations of previous ones.