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From AI Foundations to Real-World Practices

King Abdullah University of Science and Technology (KAUST)
KAUST Academy

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- Lifecycle of an AI product:
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    - Maintenance: Adapt to data drift, optimize cost & performance.

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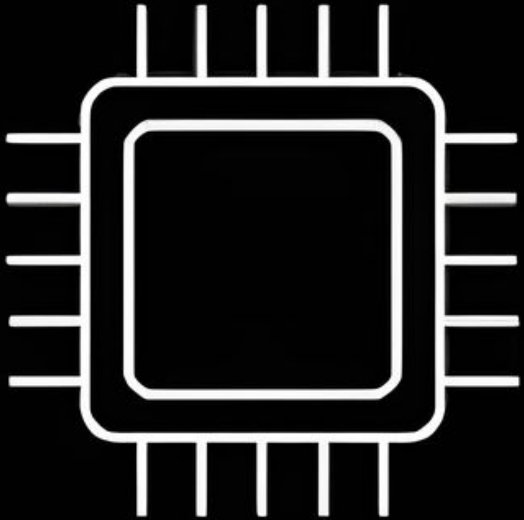
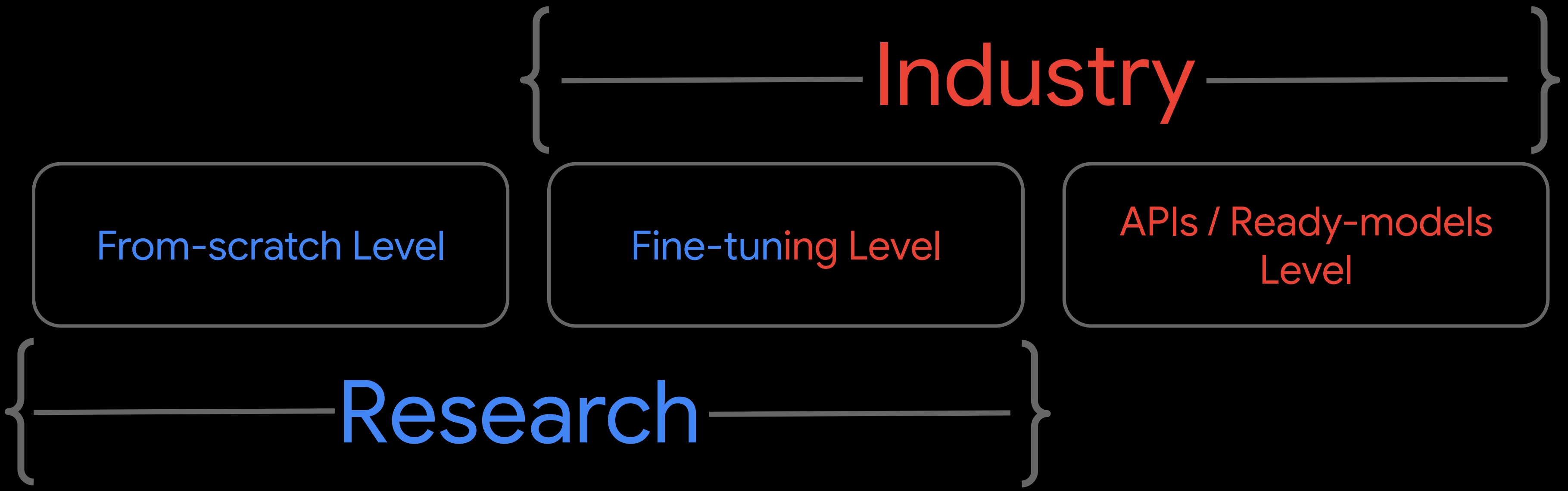
⇒ Every stage balances these constraints.

⇒ Start as simple as possible, then iterate toward the most efficient long-term solution.

Complexity & Resources Spectrum



Implementation Levels for AI Solutions



Complexity & Resources Spectrum

Level	What to do / use?	When to Choose
APIs / Ready-models Level	• Using closed-source APIs (OpenAI, Google Vertex,...) • Using zero-shot models (LLMs, SAM, Yolo-World,...) • Using publicly available models from Github / Hugging Face / ….	
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Training / Fine-tuning Level	• Training & fine-tuning models on your data. • Distilling & quantizing ready-models.	1- Idea proved to be feasible. 2- Zero-shot models are not enough for your task. 3- Have some data. 4- Can handle infrastructure. 5- Will use on private data. 6- Wants to decrease costs (it depends).
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From-scratch Level	• Training from scratch / novel architectures	1- Research novelty. 2- Unavailable model.

Open-Source vs Closed-Source

- Prototype fast?

  ⇒ Whichever gets you a demo quicker, but mostly closed-source.

- Strict data privacy or customisation need?

  ⇒ Open-source and self-host.

- Need battle-tested uptime & rapid scaling & better performance?

  ⇒ Closed-source.

Scoping a New AI Project

Scoping a New AI Project

- You just joined a company and heard:

“We need an AI solution for this problem.”

- Which clarifying questions will you ask before writing a single line of code?

Scoping a New AI Project

- What Problem Are We Solving?

  ⇒ Immerse in the domain: Let stakeholders explain the issue in their own language; capture pain-points, constraints, success criteria.

  ⇒ Translate to AI language: Re-frame domain terms into ML tasks classification, detection, ranking, forecasting, etc
  (Kaggle experience helps a lot here).

Scoping a New AI Project

- Do We Even Need AI to solve this problem?

    ⇒ Stakeholder and customers wants to through AI on everything.

    ⇒ There are many problems in real world that don't need AI at all.

    ⇒ Are you sure you want to use AI to solve a problem?

    Or just to introduce some new fancy useless feature?

Scoping a New AI Project

- Can AI Realistically Solve It?

  ⇒ Stakeholders and customers don't know the limits of AI, thinking AI can solve any problem.

  ⇒ You should know the limits of these AI models and reflect them to stakeholders to handle their expectation.

Scoping a New AI Project

- Can AI Realistically Solve It?

⇒ Stakeholders and customers don’t know the limits of AI, thinking AI can solve any problem.

⇒ You should know the limits of these AI models and reflect them to stakeholders to handle their expectation.

But, how to know if a problem is solvable by AI or not?🤔

Feasibility Checks

1. Human Baseline: Can humans do this? how well?
2. Previous Work: Papers, benchmarks, existing APIs, Kaggle competitions, public repositories.
3. Data Reality: Do we have (or can we get) labelled examples?

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Let’s see some examples…

Feasibility Checks

- Problem: I want to read all car license plate numbers.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to read all car license plate numbers.

  ⇒ Human Baseline: Very easy task, thus AI can do it as well.

  ⇒ Pipeline: Detection + OCR.

Feasibility Checks

- Problem: I want to predict the weight of an object based on its image.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to predict the weight of an object based on its image.

  ⇒ Human Baseline: Not easy. Probably with medium accuracy.

  ⇒ Pipeline: Image regression on height, width and depth. Then some math to convert to weight.

Feasibility Checks

- Problem: I want to predict the price of a house based on its color.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to predict the price of a house based on its color.

  ⇒ Human Baseline: impossible. There is no predictive signal in color.

Feasibility Checks

- Problem: I want to predict whether a user will like a specific phone.

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Feasibility Checks

- Problem: I want to predict whether a user will like a specific phone.

  ⇒ Human Baseline: Possible. I just need the user history.

  ⇒ Pipeline: Recommendation system task.

Feasibility Checks

- Problem: I want to build a model that translates cat meows into human language.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to build a model that translates cat meows into human language.

  ⇒ Human Baseline: Impossible. No ground truth.

Feasibility Checks

- Problem: I want to forecast my company's sales 10 years into the future.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to forecast my company's sales 10 years into the future.

  ⇒ Human Baseline: Extremely difficult with good accuracy. Long-term forecasting is unstable.

  ⇒ Pipeline: Time series forecasting.

Feasibility Checks

- Problem: I want to help blind people know if there's something near them.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I want to help blind people know if there's something near them.

  ⇒ Human Baseline: Possible. But I see many object in the street, which one should i describe?

  ⇒ Pipeline: Detect → Classify (needs many classes or zero-shot capabilities) → Text-to-speech.

  ⇒ Challenges: real-time processing, model size, speech quality.

Feasibility Checks

- Problem: I have characteristics of all my store branches and want to understand what makes each one special.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

- Problem: I have characteristics of all my store branches and want to understand what makes each one special.

  ⇒ Human Baseline: Possible. I can look into each store data and cluster them accordingly.

  ⇒ Pipeline: Clustering, or classification on store IDs, then analyze feature importance.

Feasibility Checks

- Problem: I want to predict if my tweet will go viral.

  ⇒ Human Baseline:

  ⇒ Pipeline:

Feasibility Checks

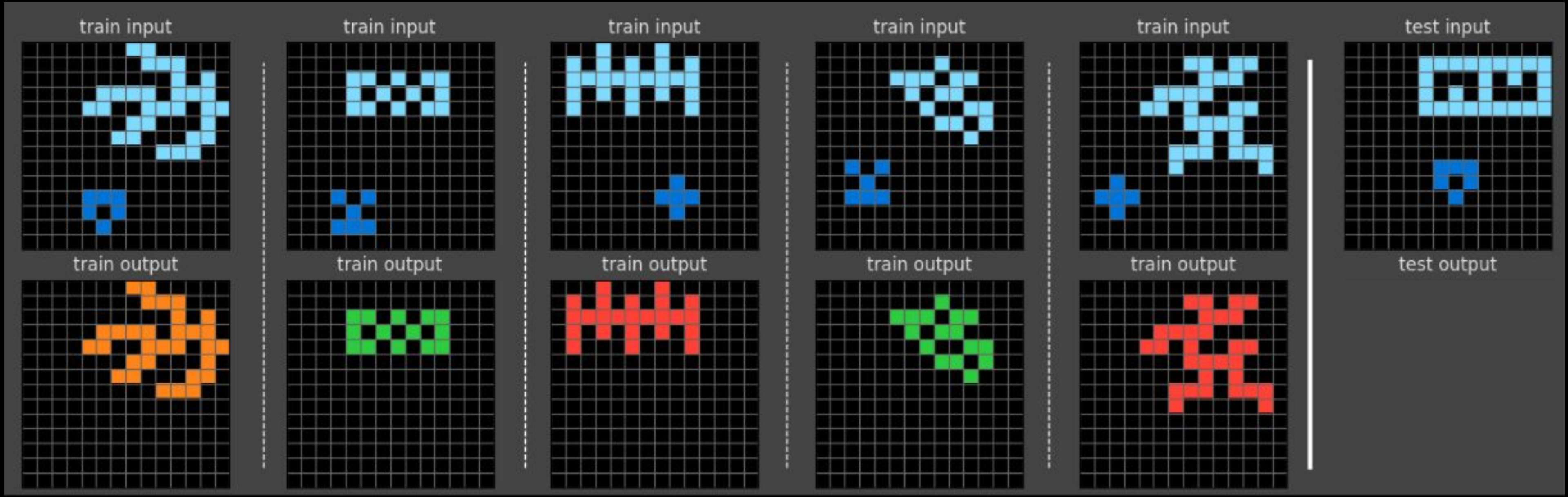
- Problem: I want to predict if my tweet will go viral.

  ⇒ Human Baseline: Maybe. Likely low accuracy.

  ⇒ Pipeline: Text classification (define what “viral” means first!)

Feasibility Checks

- Problem: I want AI to solve this puzzle:



Feasibility Checks

- Problem: I want AI to solve this puzzle:

  ⇒ Human Baseline: Very easy.

  ⇒ AI Solution: Extremely difficult!!!!!!

- This puzzle is part of a famous benchmark called ARC-AGI. All puzzles in this benchmark are easily solvable by humans, but so far, no AI has been able to solve them! link

Feasibility Checks

- Let’s get back to scoping AI problems…

Scoping a New AI Project

- Data?
    - What types of data do I need? And how much do I need to build a reliable system? ⇒ depends on the task and the availability of pretrained models.
    - Is it available? No? ⇒ Can i collect it? No? ⇒ Can I generate it? No? ⇒ Can I just use a zero-shot model to do the task?
    - Is the data quality good enough for a good model?
    - Unlabeled data? ⇒ Manual or Automatic Labeling.
    - Is the data private? No? ⇒ I can use closed-source.

Scoping a New AI Project

- What resources will be used for inference?
    - I can use GPU? ⇒ All types of solutions.
    - CPU only? ⇒ APIs + Non-DL solutions + small DL solutions (efficient and mobile architectures).
    - Edge Device? ⇒ APIs + Non-DL solutions + Extremely small DL solutions (should fit in small memory, e.g. < 64 MB).

Scoping a New AI Project

- Real-time or not?
  - Yes? ⇒ Hard problem.
    - You should decrease your models size as small as possible.
    - You should increase your inference resources as high as possible.
    - You should rely less on APIs, because of latency (it depends).
  - No? ⇒ :)

Scoping a New AI Project

- Any existing solutions?
    - Yes? ⇒ Understand it thoroughly. Consider as a baseline. Start from there.
    - No? ⇒ Search in the internet.

Scoping a New AI Project

- How to Think of Useful Features / Modeling ideas for this particular task?
    - Consider how a human would approach and solve the task.
    - Ask yourself: What information would I rely on to make an accurate decision in this context?
    - Translate that intuition into features.
    - Insights derived from human judgment often map directly to meaningful input variables.

Scoping a New AI Project

- How to evaluate the model?
    - Real data exist?
        - Yes? ⇒ evaluate on real data
        - No? Can I collect? No? Can I generate synthetic data that mimics my real world scenario?
    - <u>Fine-tuning / From-Scratch:</u> train on real / synthetic data, evaluate on real data.
    - <u>APIs:</u> no training, evaluate on real data.

Scoping a New AI Project

- What metric should I use?
    - Depends on the task (Regression, classification, retrieval,...).
    - Within each task, there are special metrics (e.g. MAE, RMSE, MAPE, SMAPE,...).
    - Each one serves a specific use case (e.g. I care about relative distance more than raw distance, MAE vs MAPE).
    - For more: link

Crafting AI Solution

- Ok, now we collected accurate information about the project. Let’s craft a solution…

Crafting AI Solution

1. Build the simplest (maybe expensive) possible solution as fast as possible end to end.

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2. Working perfectly? Start optimizing!
    a. Closed-source? ⇒ start replacing each closed-source component with an open-source one, and inspect performance difference.
    b. Resources intensive? Optimize the models sizes / input / preprocessing / GPUs-CPUs utilization.
    c. High latency? Calculate the system current latency. Consider as a baseline. Search for the bottlenecks, and keep finding lighter / faster versions.
    d. Low Accuracy? Consider closed-source / bigger models / better preprocessing / better problem formulation.

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3. Perfect? ⇒ Deploy on small scale!
4. Perfect? ⇒ Deploy on a large scale, and monitor!

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1. Start simple — end-to-end!
   a. Use an LLM with basic Q&A ability.
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    e. ❌ “Someone hacked the prompt!” ⇒

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   c. ❌ “I want it in real time.” ⇒ Optimize latency and pipeline efficiency.
   d. ❌ “The tone is too harsh for young learners.” ⇒ Fine-tune TTS or find a better one.
   e. ❌ “Someone hacked the prompt!” ⇒ Add prompt-guarding, filtering, and robustness checks.
3. When it’s stable:
   a. Deploy small-scale → Collect feedback → Iterate.
   b. Then deploy large-scale with monitoring, and keep improving.

Deployment Patterns

1. Ready-made API (OpenAI, AWS Rekognition, etc.)
    a. Model is hosted by the provider.
    b. No need to worry about scalability or infrastructure.
2. Self-hosted API (Flask / FastAPI in Docker)
    a. Custom model, hosted on your own server and exposed as an API.
    b. Full control — you must handle infrastructure, uptime, and scaling.
3. Edge / On-device (ONNX, TFLite, CoreML):
    a. Custom model runs directly on the target device.
    b. Zero network latency & strong privacy.
    c. Common in IoT and mobile deployments.

Note: Learn about cloud tools (e.g. AWS, GCP, etc.) — they're essential in real-world deployments.

Thanks for Attending!

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