Building an Intelligent System with Machine Learning

Phase 1: Problem assessment

- Determine the problem's characteristics
- Identify the main participants in the project
- Specify the project's objectives
- Determine the resource needed for building the system.

Phase 2: Data and knowledge acquisition

- Collect and analyze data and knowledge
- Make key concepts of the system design more explicit

Phase 3: Development of a prototype system

- Choose a tool for building an intelligent system
- Transform data and represent knowledge
- Design and implement a prototype system
- Test the prototype with test cases

Phase 4: Development of a complete system

- Prepare a detailed design for a full-scale system
- Collect additional data and knowledge
- Develop the user interface
- Improve the complete system

Phase 5: Evaluation and revision of the system

- Evaluate the system against the performance criteria
- Revise the system as necessary

Phase 6: Integration and maintenance of the system

- Make arrangements for technology transfer
- Establish an effective maintenance program

Image from https://flat-icons.com/wp-content/uploads/edd/2018/06/data-analytics-icons-featured.png

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- **Phase 1: Problem Assessment -**
  - Determine the problem's characteristics.

1. Problem Type

- **Diagnosis**
  Inferring malfunctions of an object from its behaviour and recommending solutions.
- **Selection**
  Ranking or Recommending the best option from a list of possible alternatives.
- **Prediction**
  Predicting the future behaviour of an object from its behaviour in the past.
- **Classification**
  Assigning an object to one of the defined classes.
- **Clustering**
  Dividing a heterogeneous group of objects into homogeneous subgroups.
- **Optimisation**
  Improving the quality of solutions until an optimal one is found.
- **Control**
  Governing the behaviour of an object to meet specified requirements in real-time.

2. Input and Output variables and their interactions

- **Tabular data**
  - Excel , CSV, SQL …
- **Image/Video/Audio**
  - Photos, Aerial Images, CCTV, Dashcam, Phone Records …
- **Text / Documents / Survey**
  - Twitter, Facebook, WeChat, CV, Reports, Books, Websites …
- **Graph Data**
  - Social networks, Power grid, Traffic, Water, Transportation, GIS …
- **3D Point Cloud**
  - CAD, LiDAR Scan, Self-driving Car …

3. Form and content of the solution

All these features are important for data scientists, engineers and programmers to choose and justify their solutions for the problem. They also affect the following steps and phases for building the intelligent system.

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- **Phase 1: Problem Assessment –** (Cont.)

participants in the project

- knowledge engineer(s) : A person capable of designing, building and testing an intelligent system.
- domain expert(s) : A knowledgeable person capable of solving problems in a specific area or domain.

project's objectives

- For example,
  1. Gaining a competitive edge.
  2. Improving the quality of decisions.
  3. Reducing labour costs.
  4. Improving the quality of products and services.

Normal resource types

1. Computer facilities.
2. Development software.
3. Knowledge and data sources (human experts, textbooks, manuals, web sites, databases and examples) .
4. Funds / money (of course)

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• Phase 2: Data and knowledge acquisition

Data Collection: A particular tool for a particular type of data.

- incompatible data: symbolic (textual) data, numerical data need to be converted into ASCII code (UTF-8, ISOXXX) and numbers as integers with single- or double- precisions floating points.
- inconsistent data: separate database, continuous variables, variables divided into several ranges, normalised to a single range.
- missing data: actual data records often contain blank fields, throw incomplete records away or infer some useful information from them or fields in with the most common or average values.
- Be careful with the imprecise and noisy data or well-defined, clean data.

Knowledge acquisition: an inherently iterative process

- reviewing documents and reading books, papers and manuals related to the problem domain.
- interviewing the domain expert.
- study and analyse the acquired knowledge, and repeat the entire process again.

Agreement on the key concepts and system design

- describe the problem-solving strategy at the most abstract, conceptual level.
- choose a tool for building a prototype: machine learning software, model and algorithm.
- do not make a detailed analysis of the problem before evaluating the prototype.

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What is a prototype?

- A prototype system can be defined as a small version of the final system. It is designed to test how well we understand the problem.
- Check the problem-solving strategy, the tool selected for building a system, and techniques for representing acquired data and knowledge are adequate to the task.
- an opportunity to persuade the sceptics and to actively engage the domain expert in the system's development.

Build the prototype

- chose a tool, massage the data and represent the acquired knowledge in the form suitable for that tool.
- design and then implement a prototype version of the system.
- examine (together with the domain expert) the prototype's performance by testing it with a variety of test cases.

What is a test case?

- A test case is a problem successfully solved in the past for which input data and an output solution are known
- During testing, the system is presented with the same input data and its solution is compared with the original solution.

Made a bad choice of the system-building tool?

- throw the prototype away and start the prototyping phase over again.
- any attempt to force an ill-chosen tool to suit a problem it wasn't designed for would only lead to further delays in the system's development.
- The main goal of the prototyping phase is to obtain a better understanding of the problem, and thus by starting this phase with a new tool, we waste neither time nor money.

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• Phase 4: Development of a complete system

Develop a full-scale system

- develop a detailed plan, schedule and budget for the complete system
- clearly define the system's performance criteria.

Addition Data and Knowledge

- adding data and knowledge to the system for special cases.

Develop user interface (UI)

- develop the user interface: the means of delivering information to a user.
- Systems may be required to:
  1. explain its reasoning process, justify its advice, analysis or conclusion.
  2. represent the results in a graphical form.

Improve the complete system

- The development of an intelligent system is an evolutionary process.
- As the project proceeds and new data and knowledge are collected and added to it, its capability improves.
- The prototype with new features will gradually evolving into the final system.
- Collect feedback to improve user experience (UX).

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- **Phase 5: Evaluation and revision of the system**

System Evaluation

- Intelligent systems, unlike conventional computer programs, are designed to solve problems that quite often do not have clearly defined 'right' and 'wrong' solutions.
- To evaluate an intelligent system is to assure that the system performs the intended task to the user's satisfaction.
- A formal evaluation of the system is normally accomplished with the test cases selected by the user.
- The system's performance is compared against the performance criteria that were agreed upon at the end of the prototyping phase.

System revision

- The evaluation often reveals the system's **limitations** and **weaknesses**, so it is revised and relevant development phases are repeated.
- Build a prototype to fix all the issues and then merge it into the system in the next update.

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System Integration and maintenance

- integrating" means interfacing a new intelligent system with existing systems within an organisation and arranging for technology transfer.
- Intelligent systems are knowledge-based systems, and because knowledge evolves over time, users need to be able to modify the system.
- learning session and Q&A session are both good choices.

Who maintains the system?

- Once the system is integrated in the working environment, the knowledge engineer withdraws from the project.
- This leaves the system in the hands of its users.
- The organisation that uses the system should have in-house expertise to maintain and modify the system.

Which tool should we use?

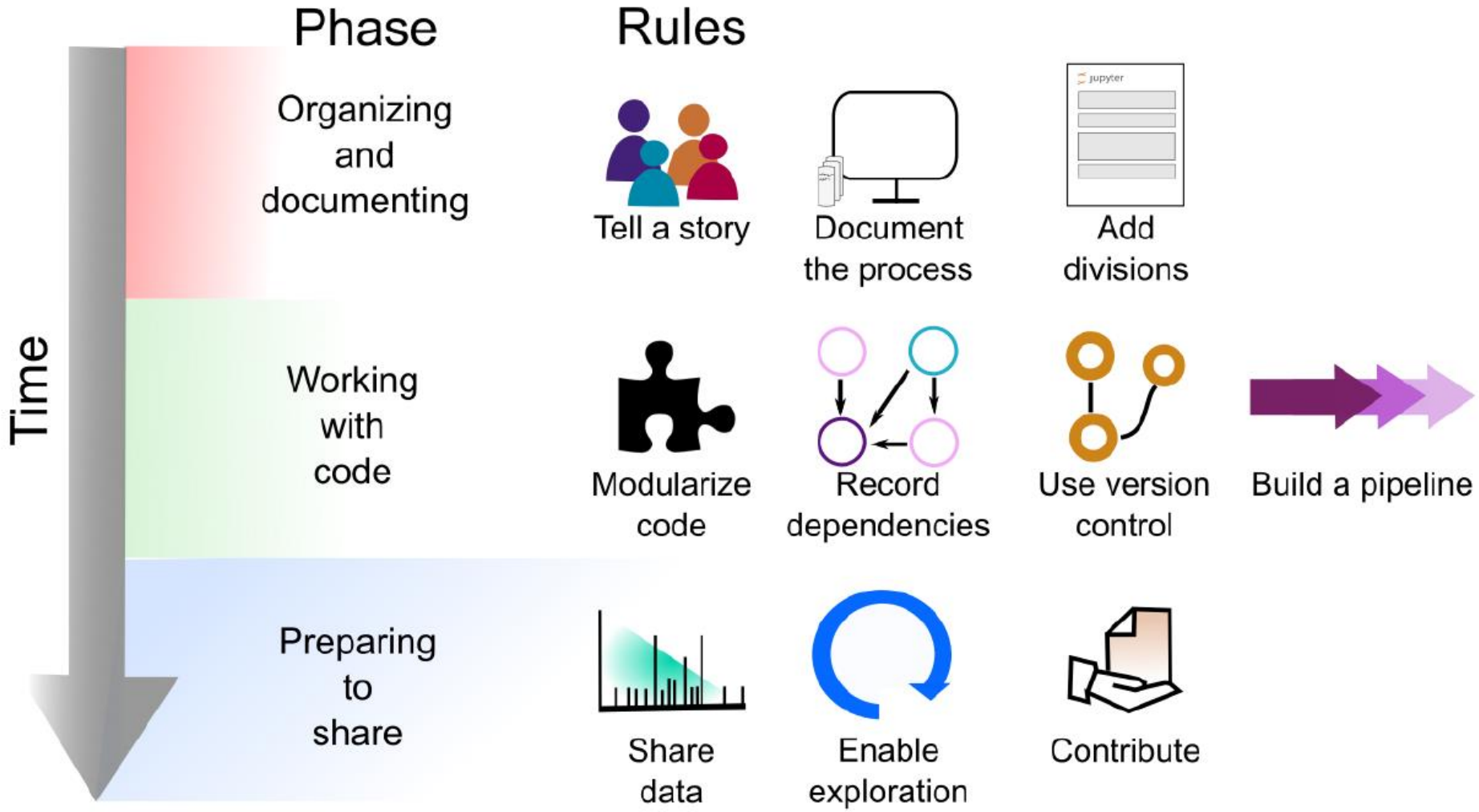
- There is no single tool that is applicable to all tasks.
- AI / Machine Learning / Deep Learning may not cover special needs.

Be real and rational

- To apply an intelligent system, one had first to find a "good" problem that has some chance for success.
- Knowledge engineering projects with AI/ML can be expensive, laborious and have high investment risks.
- Today, most general intelligent systems are built within months rather than years.
- Commercial toolboxes can run applications on standard PCs.

1. Tell a Story for an Audience
2. Document the Process, Not Just the Results
3. Add Divisions to Make Steps Clear
4. Modularize Code
5. Record Dependencies
6. Use Version Control
7. Build a Pipeline
8. Share and Explain Your Data
9. Enable Your Notebooks to Be Read, Run, and Explored
10. Contribute to Reproducible and Open Research

Ten Simple Rules for Reproducible Research in Notebooks



Demonstrate the ten rules @ https://github.com/jupyter-guide/ten-rules-jupyter