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SUMMIT 2024

Unleashing the Power of Microsoft Semantic Kernel in API Communication

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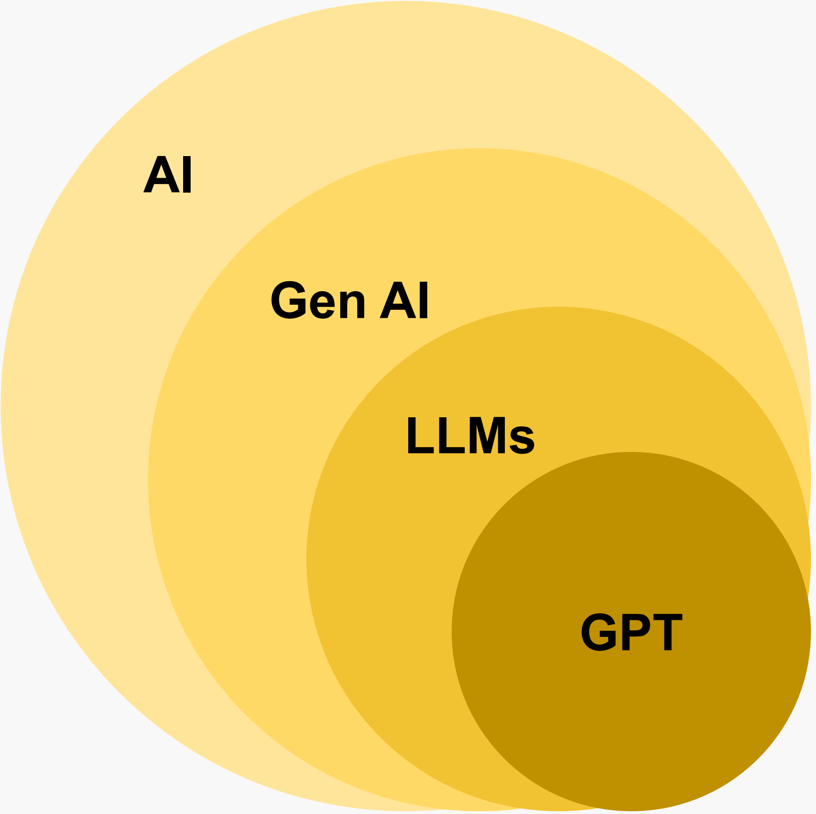
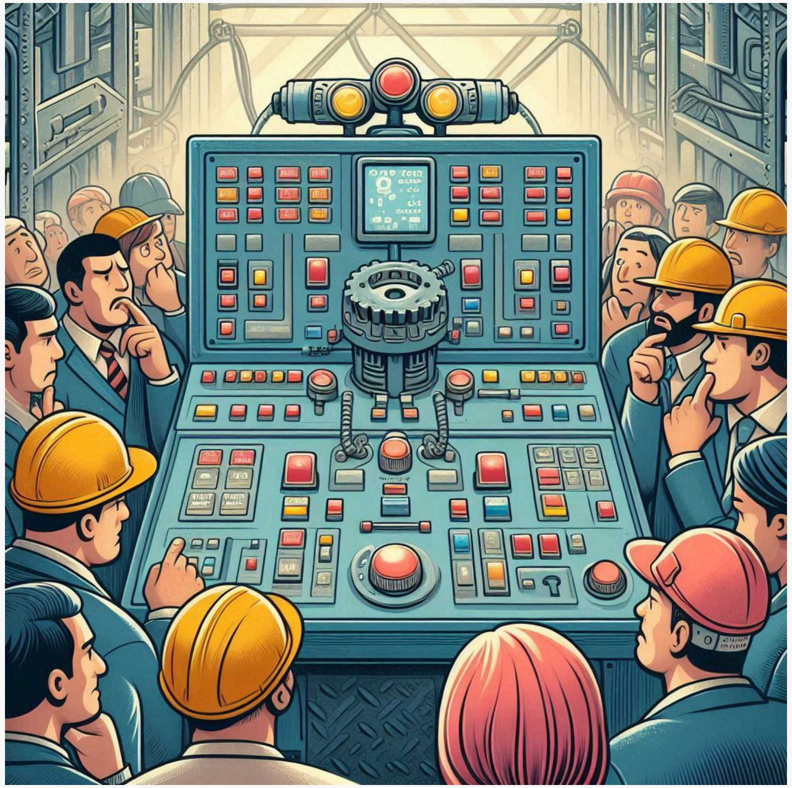
Generative AI / Large Language Models (LLMs)

- Generative AI refers to any AI system whose primary function is to generate content like **text** and **images** in response to input prompts.
- Large Language Models (LLMs) is a subset of Generative AI specialized for the generation and comprehension of human language.
  - LLM is a reasoning engine, not a knowledge store.
  - LLM is a statistical representation of knowledge.
- Generative Pre-trained Transformers (GPT) is a specific subset of LLMs, consisting of a series of models developed by OpenAI



The Problem

- Humans have a problem with machines => UI
- Finally we have a solution => semantic layer
- Coding is not natural!
- The story behind this talk



Semantic Kernel

- Microsoft's Semantic Kernel: An open-source SDK that works with **OpenAI, Azure OpenAI, Hugging Face**. Supported languages: **C#, Python, Java.**
- Advanced Features: Includes **prompt engineering**, AI **orchestrators**, recursive reasoning, and intelligent **planning** for complex problem-solving.
- Access to External Services using **connectors**: Semantic Kernel can leverage vast amounts of information from external services and data.
- Semantic Kernel relies on advanced functionalities, such as **Function Calling** and **OpenAI Assistants** and multimodal capabilities, including vision, image creation (DALL·E 3), and text-to-speech (TTS)

Semantic Kernel Features

- **Plugins** (to organize your native functions and semantic functions in plugins),
- **Function calling** (to let GPT intelligently decide when to call you functions)
- **Planners** (to generate plans to complete even more complex tasks)
- **Personas** (to generate agents, GPT-like instances, able to interact together to solve complex problems).
- **Kernel** (where all these mix together!)

Prompt Templates (Prompt Template Syntax)

- Variables (example):

```
Hello {{$name}}, welcome to Semantic Kernel!
```

- Function calls (example):

```
The weather today is {{weather.getForecast}}.
The weather today is {{weather.getForecast $input}}.
```

- Function parameters (example):

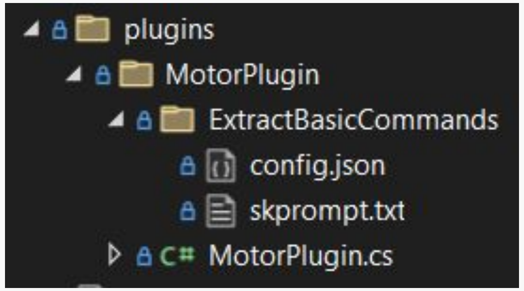
```
The weather today in {{$city}} is {{weather.getForecast $city}}.
The weather today in The Hague is {{weather.getForecast "The Hague"}}.
```

Semantic Functions (using config.json and skprompt.txt)

```
kernel.Plugins.AddFromPromptDirectory("path-to-plugin", "name");
```

skprompt

```
You are a robot car capable of performing only the following
allowed basic commands: {{ $commands }}.
Initial state of the car is stopped.
The last state of the car is stopped.
You need to:
[START ACTION TO BE PERFORMED]
{{ $input }}
[END ACTION TO BE PERFORMED]
Extract a list of basic commands from the action to be performed
to fulfill the goal. Give me the list as a comma separated list.
```



```
plugins
  MotorPlugin
    ExtractBasicCommands
      config.json
      skprompt.txt
    MotorPlugin.cs
```

config

```
{
  "schema": 1,
  "type": "completion",
  "description": "Extract basic motor commands.",
  "completion": {
    "max_tokens": 500, "temperature": 0.0,
    "top_p": 0.0, "presence_penalty": 0.0,
"frequency_penalty": 0.0
  },
  "input_variables": [
    {
      "name": "input",
      "description": "Action to be performed.",
      "is_required": true, "default": ""
    },
    {
      "name": "commands",
      "description": "The commands to choose from.",
      "is_required": true, "default": ""
    }
  ]
}
```

Native Functions

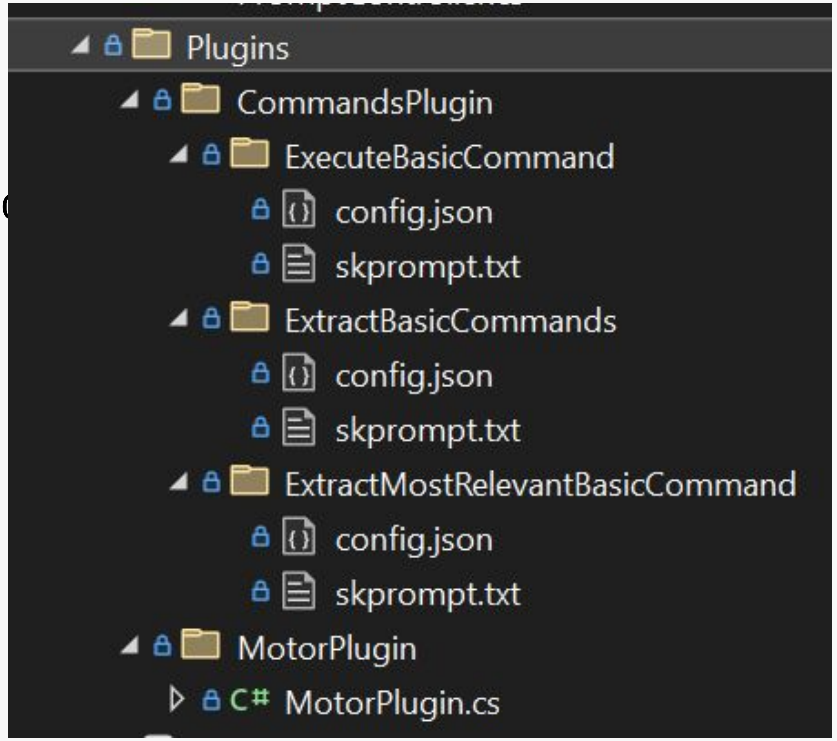
- Native code (C#, Python, Java) annotated with *KernelFunction* attribute
- Perform tasks like: retrieve data, knowing datetime, complex math, memorizing

```
kernel.Plugins.AddFromType<Plugins.MotorPlugin>();
```

```
public sealed class MotorPlugin
{
    [KernelFunction, Description("Moves the car backward.")]
    public void Backward()
    {
        // TODO call car motor API, backward endpoint
    }
    [KernelFunction, Description("Turns the car anticlockwise.")]
    public void TurnLeft()
    {
        // TODO call car motor API, turn left endpoint
    }
}
```

Plugins

- A plugin is a group of **semantic functions** (prompts), **native functions** (traditional code) or a mix between them
- Out-of-the-box plugins available as core plugins:TextPlugin, TimePlugin, MathPlugin, HttpPlugin
- Can be exported so they are usable in ChatGPT, Bing Chat and Micr 365
- More user developed plugins can be added to the kernel



```
Plugins
  CommandsPlugin
    ExecuteBasicCommand
      config.json
      skprompt.txt
    ExtractBasicCommands
      config.json
      skprompt.txt
    ExtractMostRelevantBasicCommand
      config.json
      skprompt.txt
  MotorPlugin
    MotorPlugin.cs
```

FUNCTION CALLING

Function Calling

- **A native feature of LLMs** to generate a JSON payload that includes everything you need to call a function based on the user's intent and the registered functions
- How to work with Function Calling:

1. **Register the functions** (native and semantic functions) to call with the prompt with the kernel.
2. **Sends the prompt:** Prepare and sends the prompt to identify the user's intent.
3. **Function Identification:** LLM returns a JSON payload and identifies the functions that need to be called based on the user's intent (model won't call the functions on your behalf!).
4. **Call the functions:** Matches the identified functions to call in the payload, handle any necessary computations or data retrieval, and send back a response as part of a new message.
5. **Generate final response:** The model processes the new messages which includes the function response, and generates a final response.

Function Calling with Autoinvoke

- ReAct, means that AI is going to call a function, evaluate the response and then call another function if needed
- With *Autoinvoke* (max 5 calls limit!) the function calling gets easier to implement

```
builder.Plugins.AddFromType<Plugins.MotorPlugin>();
…

var settings = new OpenAIPromptExecutionSettings
{
  ToolCallBehavior = ToolCallBehavior.AutoInvokeKernelFunctions
};

var streamingResult = kernel.InvokePromptStreamingAsync(ask, new KernelArguments(settings));
await foreach (var streamingResponse in streamingResult)
{
  Log.Debug("STREAMING: {streamingResponse}", streamingResponse);
}
```

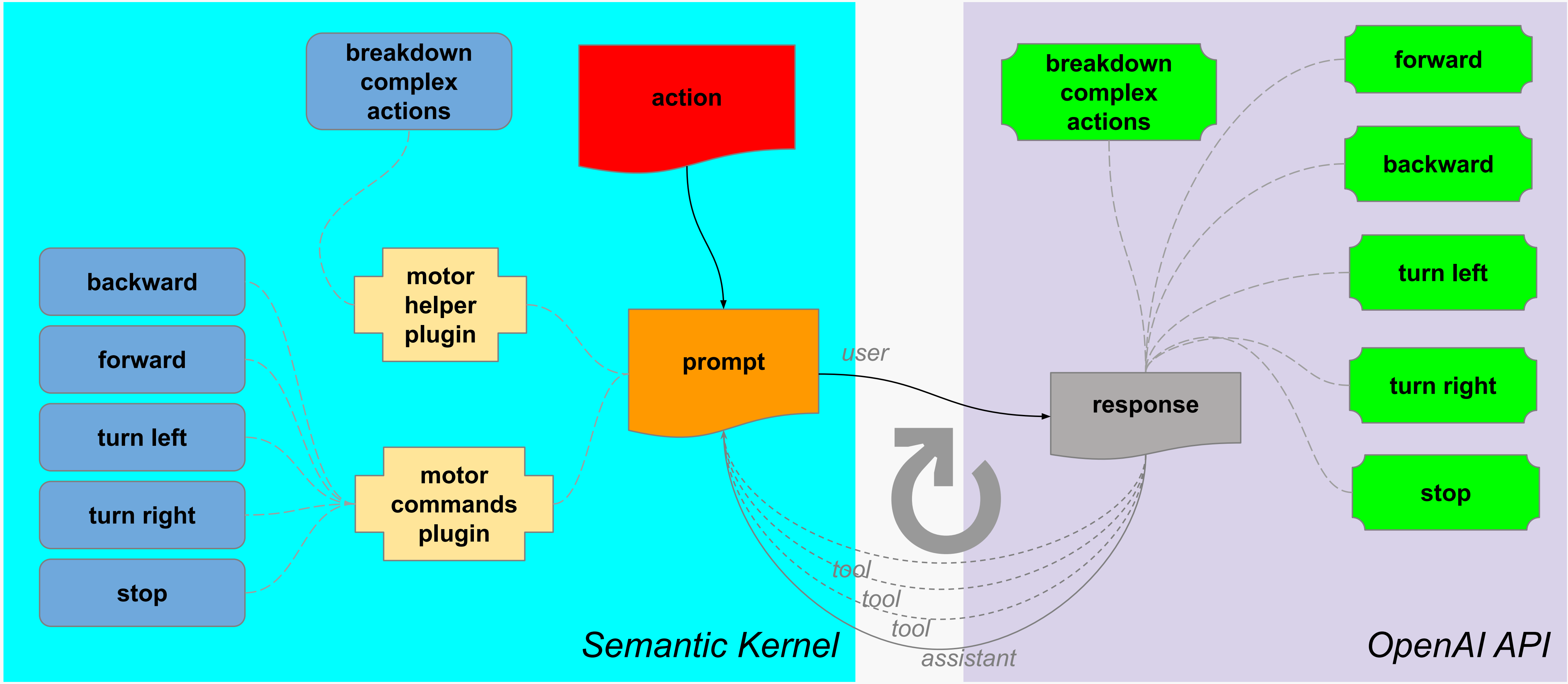
Function Calling

```
builder.Plugins.AddFromType<Plugins.MotorPlugin>();
…
var chatHistory = new ChatHistory();
chatHistory.AddMessage(AuthorRole.User, ask);

var settings = new OpenAIPromptExecutionSettings
{
  ToolCallBehavior = ToolCallBehavior.EnableKernelFunctions,
};
var chatCompletionService = kernel.GetRequiredService<IChatCompletionService>();
var result = await chatCompletionService.GetChatMessageContentAsync(chatHistory, settings, kernel);
var functionCalls = ((OpenAIChatMessageContent)result).GetOpenAIFunctionToolCalls();

foreach (var functionCall in functionCalls)
{
  kernel.Plugins.TryGetFunctionAndArguments(functionCall, out var pluginFunction, out var arguments);
  var functionResult = await clonedKernel.InvokeAsync(pluginFunction!, arguments!);
  var jsonResponse = functionResult.GetValue<object>();
  var json = JsonSerializer.Serialize(jsonResponse);
  chatHistory.AddMessage(AuthorRole.Tool, json);
}
result = await chatCompletionService.GetChatMessageContentAsync(chatHistory, settings, kernel);
```

Function calling



PLANNERS

Planners

- Orchestrator: mix-and-match the plugins/functions registered in the kernel into a series of steps that complete a goal (ReAct = Reasoning Actions)
- Out-of-the-box planners provided by Semantic Kernel include *FunctionCallingStepwisePlanner* and *HandlebarsPlanner*

FunctionCallingStepwise Planner

- An interactive planner based on LLM function calling
- An improved way of identifying the functions to call using AI reasoning
- **FunctionCallingStepwise Planner** works as follows:
    1. **Function Identification:** It identifies the functions that need to be called based on the user’s intent.
    2. **Stepwise Execution:** It executes these functions in a stepwise manner. This means it performs one function at a time, evaluates the result, and then decides on the next function to call.
    3. **Dynamic Evaluation:** It dynamically evaluates the available pathways based on the available assets.
    4. **User Goal Fulfillment:** Its ultimate goal is to fulfill a user’s request or answer a user’s question.

Handlebars Planner

- **Handlebars Planner** generates the plan ahead of the execution in one single LLM call using handlebars template language (not interactive plan!)
- Handlebars prompts work well with iterations (each) and conditions (if-else) decisions using its special syntax
    - Sandbox: https://planetcalc.com/9607/

```
{{!-- Print commands --}}

Permitted commands:
{{#each commands}}
  -  {{this}},
{{/each}}
```

```
{
  "commands": [
    "Forward",
    "Backward",
    "Turn left",
    "Turn right",
    "Stop"
  ]
}
```

```
Permitted commands:
  -  Forward,
  -  Backward,
  -  Turn left,
  -  Turn right,
  -  Stop,
```

Handlebars Planner

- *AllowLoops* allows loops in handlebars planners (not recommended with older GPT 3.5 models)

```
var handlebarsPlannerOptions = new HandlebarsPlannerOptions { AllowLoops = true };

var planner = new HandlebarsPlanner(handlebarsPlannerOptions);

var plan = await planner.CreatePlanAsync(kernel, ask);

Console.WriteLine("GENERATED PLAN: {prompt}", plan.Prompt);

result = await plan.InvokeAsync(kernel, variables);

Console.WriteLine("RESULT: {result}", result.Trim());
```

Robot Car Powered by Semantic Kernel

Direction	Arrow
Forward	→
Backward	←
Turn left	↗
Turn right	↘
Stop	▪

Example: left, right, forward, stop: ↗ ↘ → ·

DEMO

Conclusions

	Function calling w/ auto invoke	Function calling	Function calling stepwise planner	Handlebars planner
Complexity	easy	complex	easy	easy
Speed	fast	fast	slower	slow
Cost	cheap	cheap	expensive	expensive
Features	max 5 tool calls supports streaming	unlimited tool calls supports streaming	dynamic selection of tools user-defined calls limit user-defined calls interval	supports handlebars syntax review the plan before execution save the plan supports loops and statements

Resources

Semantic Kernel
https://learn.microsoft.com/en-us/semantic-kernel
https://github.com/MicrosoftDocs/semantic-kernel-docs
https://devblogs.microsoft.com/semantic-kernel
https://github.com/microsoft/semantic-kernel

Prompt engineering
https://www.promptingguide.ai

OpenAI
https://learn.microsoft.com/en-us/azure/ai-services/openai/reference
https://platform.openai.com/docs/api-reference

Demo repository
https://github.com/dcostea/Apex.RobotCarGpt

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