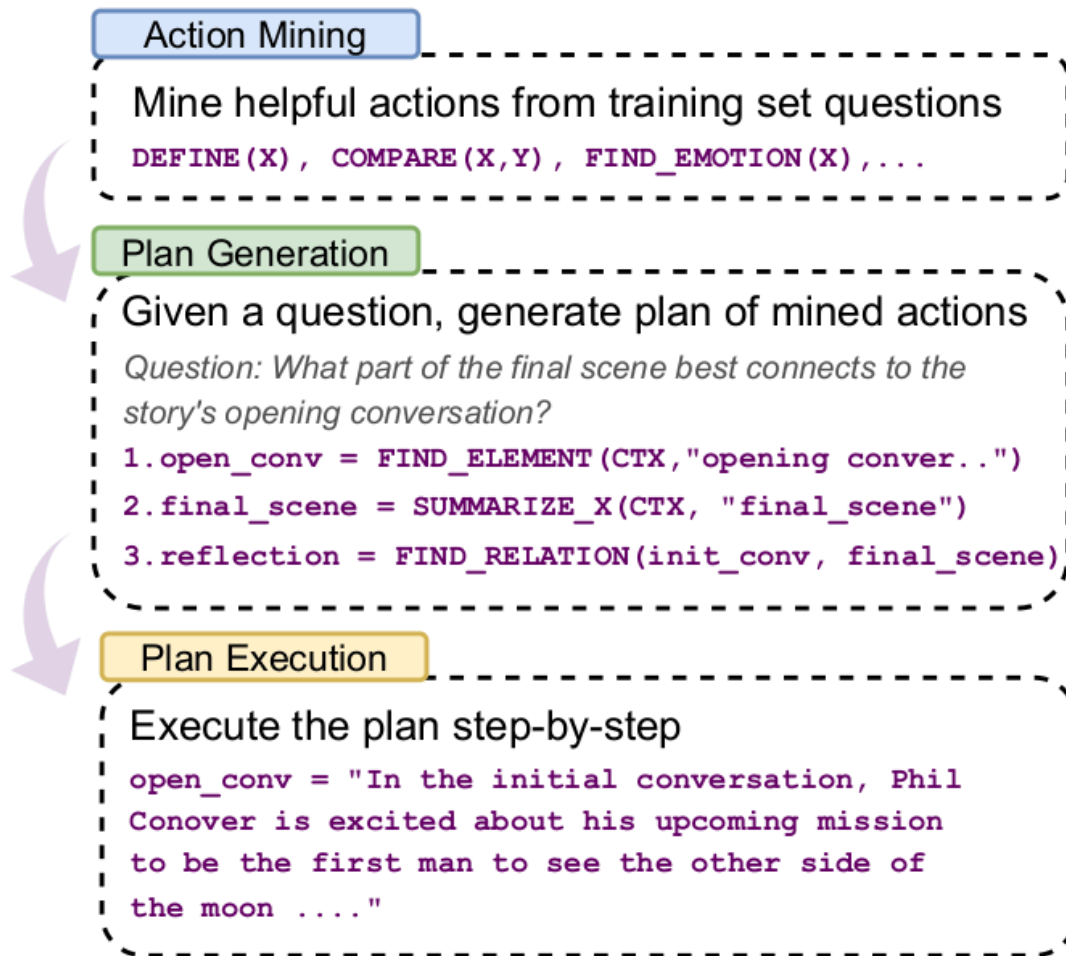


WIDTH.AI

Prompting Large Language Models to Plan and Execute Actions Over Long Documents (PEARL)

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PEARL overview (Source: [Sun et al.](#))

Using large language models (LLMs) to process long-form content like legal contracts, financial reports, books, and web content brings enormous productivity and efficiency improvements. Unfortunately, it's a problem that's not been completely solved. LLMs still face difficulties and drawbacks when processing lengthy documents.

In this article, we review the kinds of problems LLMs face and explore a technique that prompts large language models to plan and execute actions over long documents.

Problems Faced by LLMs With Long Documents

When using LLMs for long document processing, you often see issues that lead to the development of "workarounds". Some of these are due

to context length limits but you can overcome those to an extent using [chunking strategies](#).

However, there are other semantic-level drawbacks even when the document satisfies token limits. For example, if a particular concept is referred to in many sections due to its connections with other concepts, we find that straightforward prompts often ignore entire connections and sections.

Additionally, Liu et al. showed that the accuracies of LLM-generated answers [degrade with longer context lengths](#) and when relevant information is in the middle of long contexts.

In this article, we explore **planning and executable actions for reasoning over long documents** (PEARL), a technique that addresses such drawbacks through more sophisticated reasoning than naive prompts.

Introduction to PEARL

PEARL is a strategy to reason over long documents using specially crafted prompts and a small number of few-shot, in-context examples.

PEARL combines task-specific decomposition with prompt generation to create specially crafted prompts that help LLMs process complex semantic connections across the document.

Briefly, PEARL consists of three high-level stages:

1. **Action mining:** For the given complex task in a particular domain, dynamically decompose the task into a set of actions expressed like programming functions. Each action is accompanied by an instruction for the LLM and the inputs the LLM needs.
2. **Plan generation:** Form a plan consisting of these actions in the right order along with inputs and information passing. The generated plan resembles a pseudocode program.
3. **Plan execution:** Apply this action plan to the target document by asking the LLM to execute each action's instruction.

The illustration below shows one such generated plan consisting of mined actions:

```
1. gubelin = IDENTIFY_ELEMENT(CTX, "Gubelin") : Identify who Gubelin is in the input article
2. gubelin_characteristics = FIND_DESCRIPTION(CTX, "Gubelin", "characteristics") : Find and
   summarize all the characteristics of Gubelin in the input article
3. present_day = IDENTIFY_ELEMENT(CTX, "present day") : Identify the context of the present
   day in the input article
4. gubelin_outlier = FIND_OUTLIER(CTX, "Gubelin", "present day") : Find and summarize the
   aspects that make Gubelin an outlier in the present day
5. ans = CONCAT(gubelin_characteristics, gubelin_outlier) : Combine the characteristics of
   Gubelin and the aspects that make him an outlier in the present day to form the final answer
```

Example plan

We first provide some intuition into why PEARL's approach works.

Intuition Behind PEARL

Since PEARL's outputs come across as unnecessarily complicated at first glance, building some intuition may help you implement it better for your use cases.

Instead of sticking to natural language, PEARL surprises you by switching to text that resembles pseudocode or a high-level programming language:

- Actions look like functions, with input arguments and output variables.
- The generated plan looks a lot like a programming script with a particular grammar.
- Finally, the LLM is made to behave like a simulator to run that plan as if it's a program.

But why go to all this trouble? Why not stick to natural language, like [chain-of-thought prompting](#) and other strategies? Why simulate a virtual machine to run the plan?

Intuition #1 — PEARL Generates Task-Specific Semantic Pipelines

Here's a key insight that might help: Think of PEARL as a generator of task-specific text processing pipelines.

If you've worked on traditional search or text processing, you'll be familiar with expressing high-level semantic goals using low-level processing pipelines that:

1. Clean up and preprocess the raw text. Steps like removing stop words, modifying cases, or handling abbreviations are common. They're often domain- and task-specific too.
2. Find regions of semantic interest using low-level techniques like regular expressions and keyword matching. The regular expressions and keywords are selected by observing patterns in the particular text and may not be reusable across documents.
3. Extract the information you need from the regions of interest. These tend to be custom rules with plenty of conditional logic suited to the domain and task.
4. Modify the extracted information to obtain the final answer, again using more conditional logic related to the domain and task.

PEARL essentially automates the generation of such text-processing pipelines. But it goes a step further.

Recognizing that LLMs are inherently better at semantics, PEARL completely ignores low-level approximations like regular expressions. Instead, it directly uses semantic criteria and goals in actions like these examples:

- `FIND_EMOTION(CTX, X, Y)`: Find the emotion or feeling X feels towards Y given the input CTX.
- `FIND_ENDING(CTX, X)`: Find the ending or conclusion of X's story or the input CTX.
- `FIND_EVENT(CTX, X)`: Find the event involving X in the input CTX (e.g., betrayal, change, climax).

Notice how the actions are expressed in terms of high-level semantic concepts like emotions, conclusions, events, and so on.

For example, to detect emotions, most human developers would use regular expressions or string matching to search for phrases like "I/he/she/they felt angry/sad/happy." Some may use better semantic techniques like sentence-level embeddings but use conditional logic for matching. Unlike them, PEARL leverages the strong semantic capabilities of LLMs to directly search for the abstract concept of emotion.

Intuition #2 — Pseudocode Reduces Confusion

But why use pseudocode to represent these pipelines? That's to reduce ambiguity.

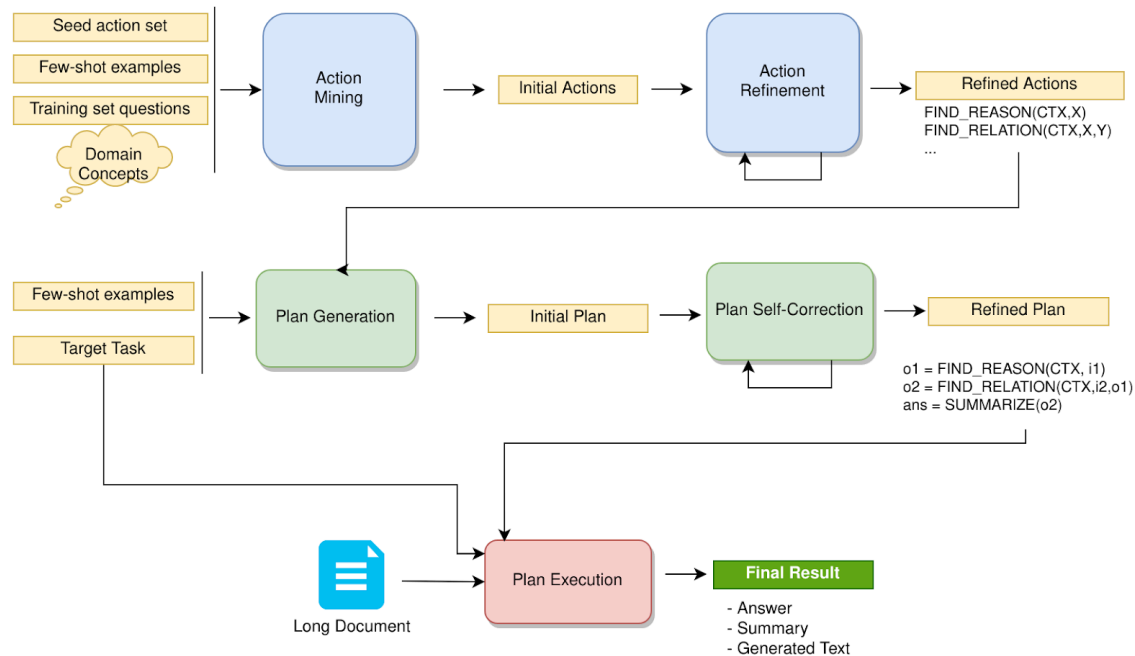
When conversing with LLMs like ChatGPT, we refer to earlier contexts using vague expressions like:

- "In the article..."
- "In your second answer..."
- "Earlier you said..."

When a conversation has multiple contexts (which is common with text processing pipelines and long documents), such vague references can confuse or mislead the LLMs. PEARL's formal pseudocode syntax eliminates such ambiguities.

How PEARL Works

PEARL consists of three primary stages but requires some secondary stages to work well.



PEARL workflow

In the following sections, we get into the mechanics of each stage, especially the input aspects and prompt engineering. But before that, it helps to understand the dataset used by the PEARL paper.

The QuALITY Long-Context Question-Answering Dataset

Though PEARL is a general-purpose prompting approach, the generated actions are specific to the domain, training dataset, and task. In particular, the PEARL research paper and code are customized for a question-answering dataset called the **QuALITY dataset**. Since the sections below show GPT-4 prompts and results generated from this dataset, let's get to know it first.

QuALITY is a human-annotated comprehension dataset based on long-form content. It contains fiction and nonfiction content from Project Gutenberg, Slate Magazine, and other sources.

Each article is accompanied by a set of related human-written questions with multiple-choice answers and best answers. The questions tend to be complex and can't be answered trivially by skimming or searching keywords.

PEARL makes use of QuALITY's articles and questions. However, instead of selecting one of the given answers, it generates a detailed long-form answer using information and relationships from all parts of the article.

Stage 1— Action Mining

In the action mining stage, the LLM is asked to generate a comprehensive set of actions that are likely to help the task at hand. It's supplied with the following information:

- A seed set of human-written actions
- Detailed instructions on what the LLM should do
- Few-shot examples that demonstrate action creation
- The target question for which the LLM must create an answering plan using a plausible set of necessary actions. However, the focus at this stage is not the plan itself but the actions and action descriptions that constitute that plan.

This prompt is repeated for each question in the training set.

The [prompt template for action mining](#) is illustrated below.

Seed actions:

{Human-written seed set of actions}

SUMMARIZE (CTX) : Provides a general summary about given CTX

FIND_REASON (CTX, X) : Find cause of X in given CTX

Instructions and demonstrations:

{Natural language instructions}

Given a question about a long document and the seed action set, come up with new actions that could help to answer the question...

{Human-written few-shot demonstrations}

Input question:

{Question from training set}

What is the alien's mission?

Output:

FIND_MISSION (CTX, X) : Find the mission of character X from the input context CTX...

Prompt template for action mining (Source: [Sun et al.](#))

Since action mining is the most important stage in PEARL, a detailed explanation for each component of the prompt follows.

Seed Set of Actions

The main purpose of the seed set is to demonstrate the pseudocode syntax for actions using function names, function call syntax, function descriptions, and arguments.

```
[Actions]
- CONCAT(S1, S2, ...) : Concatenate the input S1, S2, ...
- EXTRACT(CTX, X) : Extract the exact wording that X is referring to from input CTX.
- FIND_X(CTX, X): Find and summarize all relevant information about X in the input CTX.
- FIND_REASON(CTX, X): Find and summarize the cause or reason of X given input CTX.
- FIND_MORAL(CTX) : Find the intended lesson or moral of the input CTX.
- SUMMARIZE(CTX): Provides a general summary about the given CTX.
- SUMMARIZE_X(CTX, X) : Provides a summary about X given the provided input CTX.
```

Human-written seed set of actions

They are mostly general-purpose text processing or semantic actions, like concatenating text or finding relevant information. However, some, like FIND_MORAL, can be dataset-specific.

Action Mining Instructions

These instructions guide the LLM on using existing actions and, if necessary, generating new actions. Plus, they demonstrate the desired format for the results.

```
[Instructions]
Suppose you are given a question about an article, as well as a list of actions
that you can execute to solve the question (shown below). You can imagine the
actions as functions in a program, where you have input arguments, as well as
output. The output of an action can be fed as input to another action. The output
of the final action will be the answer to the given question. Suppose you haven't
read the article yet, please present a sequence of actions that you would use to
answer the question.

Your answer must follow the following rules:
1. The present sequence should be minimal, i.e., no unnecessary actions.
2. The sequence of actions should be specific and cover every detail about the
question.
3. The sequence of actions should use as many as existing actions as possible.
4. It is fine to create new actions, however, the created new actions should be
*maximally reusable and generalizable* to other reading comprehension questions.
5. The arguments should cover all the details of the given question.

[Answer]
Your answer should follow the format:
'''
My new actions (if any):
- my_new_action_1(here goes the arguments) : [one-sentence explanation]
- my_new_action_2(here goes the arguments) : [one-sentence explanation]
...

My sequence of actions:
1. output_1 = action_1(here goes the arguments) : [one-sentence explanation]
2. output_2 = action_2(here goes the arguments) : [one-sentence explanation]
...
'''
```

Action mining instructions and desired result format

Few-Shot Examples for Action Mining

Using sample questions and actions, the few-shot examples clarify what the LLM must do. Crucially, these must be relevant to the domain and task at hand.

```
Here are a few examples:
'''

Question:
What is the "space cafard" that Si describes?

My new actions:
- COMPREHEND(CTX, X) : Provide a detailed comprehension of X given the input CTX.

My sequence of actions:
1. snippet = EXTRACT(CTX, "space cafard") : Extract the exact wording regarding "space cafard" from the input CTX.
2. ans = COMPREHEND(CTX, X) : Provide a detailed comprehension of the input X given the input CTX.
...

'''

Question:
Why did the author write the article?

My new actions:
- None

My sequence of actions:
1. moral = FIND_MORAL(CTX) : Find the intended lesson or moral of the input CTX.
...
'''
```

Few-shot demonstrations for action mining

Notice how, unlike the seed set, the action arguments and output variables are sometimes actual examples relevant to the dataset rather than generic terms.

Input Question for Action Mining

The last component of the prompt is the training set question for which we want the LLM to discover plausible new actions while formulating an answering plan.

```
[Question]
{{question}}

[Answer]
```

Few-shot demonstrations for action mining

Example Results of Action Mining

The illustration below shows some results from action mining the QuALITY training dataset.

```
21, "My new actions:
- None

My sequence of actions:
1. snippet = EXTRACT(CTX, "something has been taken") : Extract the exact wording regarding "
2. ans = FIND X(CTX, snippet) : Find and summarize all relevant information about the extracted
22, "My new actions:
- FIND_FEELINGS(CTX, X) : Find and summarize the feelings of X in the input CTX.

My sequence of actions:
1. snippet = EXTRACT(CTX, "Shannon") : Extract the exact wording regarding "Shannon" from t
2. ans = FIND_FEELINGS(snippet, "circus") : Find and summarize the feelings of Shannon about
```

In this example, the LLM discovered that it needs a new action, FIND_FEELINGS, to answer question 22.

Stage 2 — Action Consolidation and Refinement

Action mining is run on every question in the training dataset. In QuALITY's case, we're talking about 2,100+ questions. With such a large number of questions, some generated actions may be faulty or duplicated as shown below:

```
FIND MOTIVATION(CTX, X) #Find the motivation behind X given the input CTX.
FIND MOTIVATIONS(CTX, X) #Find and list all the motivations of X given the input CTX.
```

PEARL gathers the results of action mining all the training questions. It then relies on the semantic strengths of the LLM to find duplicated or faulty actions and produce a final set of refined actions. This is the **prompt for action refinement**:

You are given a list of functions as well as their corresponding explanations. Please reduce the list by merging the functions that have the same or similar functionalities, abstract over-specific functions with unified functions. Please reduce the list by at least half.

For instance, "FIND_IMPLICATION(CTX, X)" "FIND_IMPLICATIONS(CTX, X)" can be merged to a single one function as they are essentially the same.

For another instance, "FIND_NOT_DESCRIBE(CTX, X)" is redundant because you can always use "FIND_DESCRIPTIONS(CTX, X)" and then infer the "NOT_DESCRIBE" from the descriptions returned by "FIND_DESCRIPTIONS(CTX, X)". In general, any function that contains "NOT" in the function name can be removed if there is a corresponding function that can be negated.

"FIND_RELATION(CTX, X, Y)" and "FIND_RELATIONSHIP(CTX, X, Y)" and "COMPARE_RELATIONSHIP(CTX, X, Y)" can all be merged to one function.

Given the above examples, please reduce the following list to at most one third of its current length. Please also include the definition of each function.

Actions:
{action_list}

Reduced actions:

Prompt for action refinement

The final **consolidated set of actions for the QuALITY dataset** contains about 80 actions. This limit is configurable. The paper experimented with different limits and found that for this particular dataset, 80 is an optimal number to get the best results.

Let's examine some of these 80 actions. Some are general-purpose actions:

- EXPLAIN_PROCESS(CTX, X): Provide a detailed explanation of the process X given the input CTX.
- FIND_COMMON(CTX, X, Y, Z): Find the common ground, characteristics, or commonalities between X, Y, and Z given the input CTX.

Others are dataset-specific:

- FIND_ELEMENT(CTX, X, Y): Find the element X related to Y given the input CTX. This function can cover message, method, metrics, mismatch, mission, mistake, most likely, motif, motivation, nationalities, negative critique, negative effect, next event, normal, objective, obstacles, outcome, outlier, paradox, part, perception,

personality traits, perspective, pivotal decision, plan, plausible explanations, plot, prediction, probable cause, promises, proof, protagonist, purpose, qualities, rank, reaction, reasons reception, recommendations, relation, repercussion results, role representation, sentiment thoughts, setting effect, significance, similarity, solution struggles, theme symbolism, tech advancements, tension tone, traits values, unexpected, and writing style, etc.

- `FIND_EMOTION(CTX, X, Y)`: Find the emotion or feeling X feels towards Y given the input CTX.
- `FIND_FEARS_DISTRACTIONS(CTX, X)`: Find the fears, concerns, or distractions of X given the input CTX.
- `FIND_FORESHADOW(CTX, X, Y)`: Find the instance where X foreshadows Y in the input CTX.
- `FIND_FUTURE(CTX, X)`: Find the future, predicted outcome, or action of X given the input CTX.
- `FIND_GRIEVANCE(CTX, X)`: Find and summarize the grievance X has against something or someone in the input CTX.

Stage 3 — Plan Generation

The next stage in PEARL focuses on making the LLM generate an answering plan (or task plan, in general) for a given question using the mined actions.

The [prompt template for plan generation](#) is depicted below:

Mined actions:*{Mined actions from previous stage}*

FIND_EVENT(CTX, X): Find the event involving X from input
SUMMARIZE(CTX, X): Provide a summary about X given input

Instructions and demonstrations:*{Natural language instructions}*

Given a question about a long document and the list of mined actions, come up with a plan for addressing the question below ...

*{Human-written few-shot demonstrations}***Input question:***{Question from evaluation set}*

Why does Simon look for a bottle of aspirin?

Output:

```
1. aspirin_event = FIND_EVENT(CTX, "look for...") : Find
and summarize the event where...
2. aspirin_reason = FIND_BEHAVIOR_REASON(CTX,
aspirin_event): Find the reason why ...
```

Prompt template for plan generation

We supply the full list of mined actions in the prompt.

It's followed by these detailed instructions:

```
[Instructions]
Suppose you are given a question about an article, as well as a list of potential actions (shown
above) that you can execute to solve the question . You can imagine the actions as functions in a
program, where you have input arguments, as well as output. The output of an action can be fed as
input to another action. Please present a sequence of actions that you would use to answer the
question after you read the article. The sequence of actions should be specific and cover all the
details about the question. Please prioritize using the actions presented in the list above. If you
need to add new actions, please follow the format below. Please assign the output of each action
with a distinct name, which can be passed into other actions as argument. Think twice before you
provide your answer. Make sure your answer is valid, clear, and easy to understand. Keep the answer
simple and remove any unnecessary steps. Do not use list comprehension or dictionary comprehension.
Keep each action minimally simple. If a question is unanswerable (e.g., requires options), collect
as much information as possible from the input such that it will be answerable when provided with
options. Your answer should follow the format:
\
\
\
New actions:
- new_action_1(arguments) : [one-sentence general explanation] or "-None" if there no need to add
new actions
- new_action_2(arguments) : [one-sentence general explanation] or "-None" if there no need to add
new actions

1. output_1 = action_1(here goes arguments) : [one-sentence explanation]
2. output_2 = action_2(here goes arguments) : [one-sentence explanation]
...

Please provide a plan (sequence of actions) that can arrive to the answer after reading the
article. As the corresponding options are not provided for the question, when the question is not
answerable without the options, simply collect as much information as possible from the input such
that it will be answerable with the options. Make sure the plan you generate is valid and faithful
to the question.
```

Instructions for plan generation

Notice how the instructions now focus on the plan and urge the LLM to try to use only the provided actions. However, it remains open to the possibility of new actions as well.

PEARL then includes some few-shot examples with questions and their answering plans:

```

---
Question: "Why did the author write the article?"
Answer:
New actions:
- None

1. theme = IDENTIFY_ELEMENT(CTX, "theme") : Identify the central theme of the article
2. moral = FIND_MORAL(CTX) : Identify the moral or the intended lesson from the input article
3. tone = IDENTIFY_ELEMENT(CTX, "tone") : Identify the author's tone in this article
4. target audience = IDENTIFY_ELEMENT(CTX, "target audience") : Identify the target audience of the input text
5. ans = CONCAT(theme, moral, tone, target audience) : Combine the theme, moral, tone and target audience to form the final answer

---
Question: "How many times has Critten been a Nilly?"
Answer:
New actions:
- FIND_ALL_ISSUES(CTX, X) : Find and summarize all the events where X occurs in the input article
- COUNT_X(CTX, X) : Count the number of times that X occurs in the input article

1. all nilly = FIND_ALL_ISSUES(CTX, "Critten been a Nilly") : Find and summarize all the events where Critten has been a Nilly.
2. num nilly = COUNT_X(CTX, all nilly) : Count the number of times that Critten has been a Nilly given the summarized events above.

---
Question: "Arvid 6 and Tendal 13 can perform all of the following abilities EXCEPT:"
Answer:
New actions:
- None

1. aravid 6 = IDENTIFY_ELEMENT(CTX, "Arvid 6") : Identify what Arvid 6 means in the input article
2. tendal 13 = IDENTIFY_ELEMENT(CTX, "Tendal 13") : Identify what Tendal 13 means in the input article
3. aravid 6 abilities = FIND_ELEMENT(CTX, "abilities", aravid 6) : Find and summarize all the abilities of Arvid 6
4. tendal 13 abilities = FIND_ELEMENT(CTX, "abilities", tendal 13) : Find and summarize all the abilities of Tendal 13
5. ans = CONCAT(aravid 6 abilities, tendal 13 abilities) : Combine the abilities of Arvid 6 and Tendal 13 to form the final answer for comparing with the options

```

Few-shot examples for plan generation (Source: [PEARL](#))

The default prompt for QuALITY contains 11 few-shot examples. Ideally, they must be written manually and suitable for the domain and task. However, if you prefer, the PEARL code has a "refine" function to autogenerate these few-shot examples from a dataset.

Finally, we append the question for which we want the LLM to generate a plan using the mined actions.

Importantly, we do not provide the full article as input at this stage. The plan is generated using just the mined actions, the target question, and the few-shot examples.

Plan Generation Example

An example question from QuALITY and its generated plan are shown below:

```
[Question]
Now you are given a question about an article:
What makes Gubelin an outlier in the present day?
Please provide a plan (sequence of actions) that can arrive to the answer after reading the article. As
the corresponding options are not provided for the question, when the question is not answerable without
the options, simply collect as much information as possible from the input such that it will be answerable
with the options. Make sure the plan you generate is valid and faithful to the question.

[Answer]

New actions:
- None

1. gubelin = IDENTIFY_ELEMENT(CTX, "Gubelin") : Identify who Gubelin is in the input article
2. gubelin_characteristics = FIND_DESCRIPTION(CTX, "Gubelin", "characteristics") : Find and summarize all
the characteristics of Gubelin in the input article
3. present_day = IDENTIFY_ELEMENT(CTX, "present day") : Identify the context of the present day in the
input article
4. gubelin_outlier = FIND_OUTLIER(CTX, "Gubelin", "present day") : Find and summarize the aspects that
make Gubelin an outlier in the present day
5. ans = CONCAT(gubelin_characteristics, gubelin_outlier) : Combine the characteristics of Gubelin and the
aspects that make him an outlier in the present day to form the final answer
```

Example generated plan

In this example, the LLM has expressed the plan using only the mined actions. Further, it has replaced the action parameters with question-specific arguments.

Stage 4 — Plan Self-Correction

With just a small number of few-shot examples and complex instructions for the LLM, a generated plan may have problems like:

- Unknown actions
- Wrong number of arguments for an action
- Wrong ordering of actions

So, PEARL follows this iterative self-correction strategy:

1. Evaluate the plan using validation rules for action names and arguments.
2. If the plan is deemed invalid, prepare suitable text error messages to describe the problems.
3. Generate a new plan. But provide the invalid plan and error messages too so that the LLM can self-correct those errors.
4. Repeat these steps for a few iterations (seven by default) until the plan is valid.

At the end, you'll have a self-corrected plan that has the correct syntax and grammar. Note that even at this stage, the long document isn't used.

The [prompt for plan self-correction](#) is very similar to plan generation but with these self-correcting instructions:

```
[Question]
Given the following question,
Question: {question}
you just came up with the following sequence of actions as well as potential new actions:
{invalid_plan}

However, the above answer is invalid according to a parser, which returned an error message
"{error_message}". Previously, you have also received error messages displayed below with
other invalid plans:
{all_error_messages}

Can you edit the plan (sequence of actions) to make it valid and improve it if it is not
perfect enough? Please read all the actions and their definitions carefully. Make sure that
your modified plan complies with the instructions and formats shown above.
```

Instructions for plan self-correction (Source: [PEARL](#))

Plan Self-Correction Example

In this example, the LLM finds syntax errors over two iterations:

```
New actions:
- None

1. gubelin = IDENTIFY_ELEMENT(CTX, "Gubelin") : Identify who Gubelin is in the input article
2. gubelin_characteristics = FIND_DESCRIPTION(CTX, "Gubelin", "characteristics") : Find and
summarize all the characteristics of Gubelin in the input article
3. present_day = IDENTIFY_ELEMENT(CTX, "present day") : Identify the context of the present
day in the input article
4. gubelin_outlier = FIND_ELEMENT(CTX, "outlier", "Gubelin") : Find and summarize the
aspects that make Gubelin an outlier in the present day
5. outlier_relation = FIND_RELATION(CTX, gubelin outlier, present day) : Find and summarize
the relationship between Gubelin's outlier aspects and the present day context
6. ans = CONCAT(gubelin_characteristics, outlier_relation) : Combine the characteristics of
Gubelin and the relationship between his outlier aspects and the present day context to form
the final answer

Error parsing action FIND_DESCRIPTION. Number of arguments is incorrect
---
```

```
New actions:
- None

1. gubelin = IDENTIFY_ELEMENT(CTX, "Gubelin") : Identify who Gubelin is in the input article
2. gubelin_characteristics = FIND_DETAILS(CTX, "Gubelin") : Find and summarize all the
characteristics of Gubelin in the input article
3. present_day = IDENTIFY_ELEMENT(CTX, "present day") : Identify the context of the present
day in the input article
4. gubelin_outlier = FIND_ELEMENT(CTX, "outlier", "Gubelin") : Find and summarize the
aspects that make Gubelin an outlier in the present day
5. outlier_relation = FIND_RELATION(CTX, gubelin outlier, present day) : Find and summarize
the relationship between Gubelin's outlier aspects and the present day context
6. ans = CONCAT(gubelin_characteristics, outlier_relation) : Combine the characteristics of
Gubelin and the relationship between his outlier aspects and the present day context to form
the final answer

Error parsing action FIND_DETAILS. Number of arguments is incorrect
```

Invalid generated plans

In the end, it generates this correct plan:

```

New actions:
- None

1. gubelin = IDENTIFY_ELEMENT(CTX, "Gubelin") : Identify who Gubelin is in the input article
2. gubelin characteristics = FIND_ELEMENT(CTX, "characteristics", "Gubelin") : Find and summarize all the characteristics of Gubelin in the input article
3. present_day = IDENTIFY_ELEMENT(CTX, "present day") : Identify the context of the present day in the input article
4. gubelin present day relation = FIND_RELATION(CTX, gubelin characteristics, present day) : Find and summarize the relationship between Gubelin's characteristics and the present day context
5. gubelin outlier reason = FIND_COMMON(CTX, gubelin characteristics, present day, "exception") : Find the aspects that make Gubelin an outlier in the present day context by looking for exceptions
6. ans = CONCAT(gubelin present day relation, gubelin outlier reason) : Combine the relationship between Gubelin's characteristics and the present day context, and the aspects that make him an outlier to form the final answer

```

Final corrected plan

Stage 5 — Plan Execution

The last stage is to apply the plan's actions to the supplied document to get the result. PEARL examines the actions of the plan and replaces all CTX arguments with the supplied document.

After that, each action is run by the LLM one by one based on the action description, and its results are assigned to generated output variables.

The execution trace below shows the first three actions and their results for our example plan:

```

{'action': 'IDENTIFY_ELEMENT', 'args': ['CTX', '"Gubelin"'], 'output_var': 'gubelin', 'detailed_action': 'Identify who Gubelin is in the input article'}

Gubelin, also referred to as Academician Gubelin and Doc Gubelin, is a character in the input article who is closely associated with the Department of Space Exploration. He is a colleague and friend of Doctor Hans Girard-Perregaux, and together they discuss the challenges of finding a space pilot to continue their space exploration program. Gubelin is described as a living anachronism and is possibly the only living man on North America who still wears spectacles. He is also known for his appreciation of antique items, such as the gold watch he gives to Si Pond upon his retirement.
=====
{'action': 'FIND_ELEMENT', 'args': ['CTX', '"characteristics"', '"Gubelin"'], 'output_var': 'gubelin characteristics', 'detailed_action': 'Find and summarize all the characteristics of Gubelin in the input article'}

Gubelin is a living anachronism who still wears spectacles, as he has a phobia against having his eyes touched, which prevents him from undergoing surgery or using contact lenses. He longs for yesteryear and is nostalgic about the past. He is an academician and works in the Department of Space Exploration alongside his friend and colleague, Hans Girard-Perregaux. Gubelin is passionate about space exploration and is concerned about the lack of courageous young men willing to take risks and face adventure. He is also quite resourceful and persistent in trying to find ways to bring Seymour Pond out of retirement to continue space exploration.
=====
{'action': 'IDENTIFY_ELEMENT', 'args': ['CTX', '"present day"'], 'output_var': 'present_day', 'detailed_action': 'Identify the context of the present day in the input article'}

In the input article, the context of the "present day" refers to the time period in which the story is set, which is a futuristic society known as the Ultrawelfare State. In this society, automation has taken over most jobs, and people are provided with a basic income through shares in the economy. The protagonist, Si Pond, is a space pilot who has recently retired and is living in this society. The story explores the challenges faced by the Space Exploration Department in convincing Si to come out of retirement, as well as Si's experiences in this futuristic world.
=====

```

The first three steps of example plan execution

Here are the next two steps of the example six-step plan:

```
{'action': 'FIND_RELATION', 'args': ['CTX', 'gubelin characteristics', 'present day'], 'output_var': 'gubelin present day relation', 'detailed action': "Find and summarize the relationship between Gubelin's characteristics and the present day context"}
```

The relationship between Gubelin's characteristics and the present day context lies in the contrast between his nostalgic longing for the past and the futuristic society of the Ultrawelfare State. Gubelin's anachronistic tendencies, such as wearing spectacles and longing for yesteryear, set him apart from the majority of people in this highly automated society where most jobs are taken over by machines and people are provided with a basic income. His passion for space exploration and concern about the lack of courageous young men willing to take risks also highlights the complacency and lack of ambition prevalent in the Ultrawelfare State. Gubelin's resourcefulness and persistence in trying to bring Si Pond out of retirement to continue space exploration further emphasizes the challenges faced by the Space Exploration Department in this futuristic society, where people are more focused on their own comfort and security than on pursuing adventure and progress.

```
=====
{'action': 'FIND_COMMON', 'args': ['CTX', 'gubelin characteristics', 'present day', '"exception"'], 'output_var': 'gubelin outlier reason', 'detailed action': "Find the aspects that make Gubelin an outlier in the present day context by looking for exceptions"}
```

Gubelin is an exception in the present day Ultrawelfare State society due to several factors. Firstly, he is a living anachronism who still wears spectacles, which is a rarity in this futuristic society where most people have undergone surgery or use contact lenses to correct their vision. His phobia against having his eyes touched sets him apart from the majority of the population who have embraced technological advancements in eye care.

Secondly, Gubelin's longing for yesteryear and nostalgia for the past make him an outlier in a society that is focused on automation and technological progress. His appreciation for antique items, such as the gold watch he gives to Si Pond, further highlights his attachment to the past.

Thirdly, Gubelin's passion for space exploration and concern about the lack of courageous young men willing to take risks and face adventure is not shared by many in the Ultrawelfare State. Most people in this society are content with their basic income and have little interest in pursuing dangerous occupations like space travel.

Lastly, Gubelin's resourcefulness and persistence in trying to bring Si Pond out of retirement to continue space exploration demonstrate his dedication to the cause, which is not common in a society where most people are focused on their own comfort and security. Overall, Gubelin's characteristics and values make him an exception in the context of the Ultrawelfare State society.

The next two steps of example plan execution

Example Plan Result

The final execution step produces the result for the question we asked ("What makes Gubelin an outlier in the present day?"):

```
{'action': 'CONCAT', 'args': ['gubelin present day relation', 'gubelin outlier reason'], 'output_var': 'ans', 'detailed action': "Combine the relationship between Gubelin's characteristics and the present day context, and the aspects that make him an outlier to form the final answer"}
```

The relationship between Gubelin's characteristics and the present day context lies in the contrast between his nostalgic longing for the past and the futuristic society of the Ultrawelfare State. Gubelin's anachronistic tendencies, such as wearing spectacles and longing for yesteryear, set him apart from the majority of people in this highly automated society where most jobs are taken over by machines and people are provided with a basic income. His passion for space exploration and concern about the lack of courageous young men willing to take risks also highlights the complacency and lack of ambition prevalent in the Ultrawelfare State. Gubelin's resourcefulness and persistence in trying to bring Si Pond out of retirement to continue space exploration further emphasizes the challenges faced by the Space Exploration Department in this futuristic society, where people are more focused on their own comfort and security than on pursuing adventure and progress.

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PEARL for Medical Report Question Answering

In this section, we explore how PEARL performs in the question and answer domain. This is a pretty common use case for longer context windows. Engineering these systems spends a ton of time on adjusting both the chunk parameters (size, splitting, keywords etc), and the structure of how these chunks are pulled into the context window. Some systems struggle due to the fact that the most relevant chunks aren't always the ones that best answer the question. If the database has multiple medical reports for different patients, or the same patient but different visits, the similar chunks that get retrieved might all be exactly the same section, **when the query actually requires various parts of the document.**

Adapting PEARL

We know the inputs that are either domain-specific or manually supplied:

- Seed set of actions for action mining
- Domain-specific training questions for action mining
- Few-shot examples for action mining
- Few-shot examples for plan generation
- Relevant long documents

To prepare these inputs, we first look for suitable medical datasets.

Medical Datasets

We get our long documents — medical reports — from the Kaggle [medical transcriptions dataset](#) that we have used earlier for [summarization](#) work:

HISTORY OF PRESENT ILLNESS: , I have seen ABC today. He is a very pleasant gentleman who is 42 years old, 344 pounds. He is 5'9". He has a BMI of 51. He has been overweight for ten years since the age of 33, at his highest he was 358 pounds, at his lowest 260. He is pursuing surgical attempts of weight loss to feel good, get healthy, and begin to exercise again. He wants to be able to exercise and play volleyball. Physically, he is sluggish. He gets tired quickly. He does not go out often. When he loses weight he always regains it and he gains back more than he lost. His biggest weight loss is 25 pounds and it was three months before he gained it back. He did six months of not drinking alcohol and not taking in many calories. He has been on multiple commercial weight loss programs including Slim Fast for one month one year ago and Atkin's Diet for one month two years ago.,

PAST MEDICAL HISTORY: , He has difficulty climbing stairs, difficulty with airline seats, tying shoes, used to public seating, difficulty walking, high cholesterol, and high blood pressure. He has asthma and difficulty walking two blocks or going eight to ten steps. He has sleep apnea and snoring. He is a diabetic, on medication. He has joint pain, knee pain, back pain, foot and ankle pain, leg and foot swelling. He has hemorrhoids.,

PAST SURGICAL HISTORY: , Includes orthopedic or knee surgery.,

SOCIAL HISTORY: , He is currently single. He drinks alcohol ten to twelve drinks a week, but does not drink five days a week and then will binge drink. He smokes one and a half pack a day for 15 years, but he has recently stopped smoking for the past two weeks.,

FAMILY HISTORY: , Obesity, heart disease, and diabetes. Family history is negative for hypertension and stroke.,

CURRENT MEDICATIONS: , Include Diovan, Crestor, and Tricor.,

MISCELLANEOUS/EATING HISTORY: ,He says a couple of friends of his have had heart attacks and have had died. He used to drink everyday, but stopped two years ago. He now only drinks on weekends. He is on his second week of Chantix, which is a medication to come off smoking completely. Eating, he eats bad food. He is single. He eats things like bacon, eggs, and cheese, cheeseburgers, fast food, eats four times a day, seven in the morning, at noon, 9 p.m., and 2 a.m. He currently weighs 344 pounds and 5'9". His ideal body weight is 160 pounds. He is 184 pounds overweight. If he lost 70% of his excess body weight that would be 129 pounds and that would get him down to 215.,

REVIEW OF SYSTEMS: , Negative for head, neck, heart, lungs, GI, GU, orthopedic, or skin. He also is positive for gout. He denies chest pain, heart attack, coronary artery disease, congestive heart failure, arrhythmia, atrial fibrillation, pacemaker, pulmonary embolism, or CVA. He denies venous insufficiency or thrombophlebitis. Denies shortness of breath, COPD, or emphysema. Denies thyroid problems, hip pain, osteoarthritis, rheumatoid arthritis, GERD, hiatal hernia, peptic ulcer disease, gallstones, infected gallbladder, pancreatitis, fatty liver, hepatitis, rectal bleeding, polyps, incontinence of stool, urinary stress incontinence, or cancer. He denies cellulitis, pseudotumor cerebri, meningitis, or encephalitis.,

PHYSICAL EXAMINATION: ,He is alert and oriented x 3. Cranial nerves II-XII are intact. Neck is soft and supple. Lungs: He has positive wheezing bilaterally. Heart is regular rhythm and rate. His abdomen is soft. Extremities: He has 1+ pitting edema.,

IMPRESSION/PLAN: , I have explained to him the risks and potential complications of laparoscopic gastric bypass in detail and these include bleeding, infection, deep venous thrombosis, pulmonary embolism, leakage from the gastrojejunum-anastomosis, jejunojejuno-anastomosis, and possible bowel obstruction among other potential complications. He understands. He wants to proceed with workup and evaluation for laparoscopic Roux-en-Y gastric bypass. He will need to get a letter of approval from Dr. XYZ. He will need to see a nutritionist and mental health worker. He will need an upper endoscopy by either Dr. XYZ. He will need to go to Dr. XYZ as he previously had a sleep study. We will need another sleep study. He will need H. pylori testing, thyroid function tests, LFTs, glycosylated hemoglobin, and fasting blood sugar. After this is performed, we will submit him for insurance approval.

Sample medical report

We choose the longest reports that are 12,000-16,000 tokens.

The input question will be a complex one: How is the medical condition affecting their lifestyle and what changes should the patient make in their lifestyle?

I love this question for evaluation because it is abstract enough that it causes a few key issues that you see with these Q&A systems:

- The specific medical condition is not specified. Keyword heavy systems or systems with limited domain knowledge will struggle with this.
- The first question is vague and does not give a direct correlation to anything in the document. This means the LLM requires in-domain knowledge of how to correlate different parts of the context to the query.

- The model has two options for what makes the most sense to answer the second part of the question. Either it can find a summary in the provided context and perform an answer extraction, or if this cannot be found, summarize multiple sections into an answer. This requires a deep level of understanding of the input text relative to the query.
- Multiple questions in the same query. One of the places where RAG based systems struggle. The model has to pull in context for both parts of the question.

That leaves us with questions and few-shot plans for action mining and plan generation. We use the **MEDIQA-AnS** (MEDIQA-Answer Summarization) dataset by Savary et al. because:

- It contains questions from laypersons regarding medical problems. While some of these are quite long with a conversational tone, it's possible to summarize and simplify them to short questions.
- It contains detailed long-form answers sourced from medical experts or extracted from articles by medical experts.
- Simple, short, expert-created summaries of those complex answers are available.
- Each pair of long-form answer and its simple summary enables us to prepare an answering plan that maps the question to the answer.

A sample entry from MEDIQA-AnS is shown below:

Original question: Absence seizures Does any damage occur from these spells. Mental or physical
Simplified question: Does any mental or physical damage occur from absence seizure spells?
Summary of answers: Absence seizures may affect ability to learn, daily activities, ability to drive, and bathe or swim alone.
Long-form answer: Absence seizure Overview Absence seizures involve brief, sudden lapses of consciousness. They're more common in children than in adults. Someone having an absence seizure may look like he or she is staring blankly into space for a few seconds. Then, there is a quick return to a normal level of alertness. This type of seizure usually doesn't lead to physical injury. Absence seizures usually can be controlled with anti-seizure medications. Some children who have them also develop other seizures. Many children outgrow absence seizures in their teens. Symptoms An indication of simple absence seizure is a vacant stare, which may be mistaken for a lapse in attention that lasts about 10 seconds, though it may last as long as 20 seconds, without any confusion, headache or drowsiness afterward. Signs and symptoms of absence seizures include: - Sudden stop in motion without falling - Lip smacking - Eyelid flutters - Chewing motions - Finger rubbing - Small movements of both hands Afterward, there's no memory of the incident. Some people have many episodes daily, which interfere with school or daily activities. A child may have absence seizures for some time before an adult notices the seizures, because they're so brief. A decline in a child's learning ability may be the first sign of this disorder. Teachers may comment about a child's inability to pay attention or that a child is often daydreaming. Contact your doctor: - The first time you notice a seizure - If this is a new type of seizure - If the seizures continue to occur despite taking anti-seizure medication Contact 911 or emergency services in your area: - If you observe prolonged automatic behaviors lasting minutes to hours - activities such as eating or moving without awareness - or prolonged confusion, possible symptoms of a condition called absence status epilepticus - After any seizure lasting more than five minutes Causes Many children appear to have a genetic predisposition to absence seizures. In general, seizures are caused by abnormal electrical impulses from nerve cells (neurons) in the brain. The brain's nerve cells normally send electrical and chemical signals across the synapses that connect them. In people who have seizures, the brain's usual electrical activity is altered. During an absence seizure, these electrical signals repeat themselves over and over in a three-second pattern. People who have seizures may also have altered levels of the chemical messengers that help the nerve cells communicate with one another (neurotransmitters). Risk factors Certain factors are common to children who have absence seizures, including: - Age. Absence seizures are more common in children between the ages of 4 and 14. - Sex. Absence seizures are more common in girls. - Family members who have seizures. Nearly half of children with absence seizures have a close relative who has seizures. Diagnosis Your doctor will ask for a detailed description of the seizures and conduct a physical exam. Tests may include: - Electroencephalography (EEG). This painless procedure measures waves of electrical activity in the brain. Brain waves are transmitted to the EEG machine via small electrodes attached to the scalp with paste or an elastic cap. Rapid breathing (hyperventilation) during an EEG study can trigger an absence seizure. During a seizure, the pattern on the EEG differs from the normal pattern. - Brain scans. In absence seizures, brain-imaging studies, such as magnetic resonance imaging (MRI), will be normal. But tests such as MRI can produce detailed images of the brain, which can help rule out

Medical Action Mining

For the medical seed set of actions, we reuse most of the seed set as PEARL since they're generic except for FIND_MORAL which isn't relevant for medical data.

For the few-shot examples, we extract questions from 30 random entries in MEDIQA-AnS primary dataset file and apply action mining to them. The results look quite promising:

```

PROGNOSIS(CTX, X)      #Find information about the prognosis and chances of recovery for X in the input CTX.
HARMFUL_EFFECTS(CTX, X) #Find and summarize the harmful effects of X in the input CTX.
DIAGNOSE(CTX, X)       #Find diagnostic tests for X given the input CTX.
PREVALENCE(CTX, X)     #Find the prevalence or commonness of X in the input CTX.
STOP_USING(CTX, X)     #Find recommendations and steps to stop using X given the input CTX.
TRANSMISSION(CTX, X)   #Find information about how X is transmitted or caught given the input CTX.
TREATMENT(CTX, X)      #Find treatment options for X in the input CTX.
EFFECTIVENESS(CTX, X)  #Find information about the effectiveness and success of X in the input CTX.
INHERITANCE(CTX, X)    #Find information about how X is inherited or passed down in the input CTX.
COMPATIBILITY(CTX, X, Y) #Find information about the compatibility of X and Y in the input CTX.
CAUSES(CTX, X)         #Find the causes of X in the input CTX.
PREVENTION(CTX, X)     #Find prevention methods for X in the input CTX.
SCREEN(CTX, X)         #Find screening methods for X given the input CTX.
CAUSE(CTX, X)          #Find and summarize the cause or factors leading to X given input CTX.
TREATMENT_OPTIONS(CTX, X) #Find possible treatment options for X in the input CTX.
TREAT_CAUSE(CTX, X, Y) #Find treatment plans for X caused by Y in the input CTX.
PREVENT(CTX, X)        #Find ways to prevent or reduce the risk of X in the input CTX.
TEST(CTX, X)           #Find testing methods for X given the input CTX.
DOCTORS_CONSENSUS(CTX, X) #Find the consensus of medical doctors on X in the input CTX.
ADMINISTER(CTX, X)     #Find the method of administering X given the input CTX.
SUPPORT(CTX, X)        #Find support resources and groups for X in the input CTX.

```

Initial list of mined medical actions

Medical Plan Generation

We supply these few-shot examples in the plan generation prompt:

```
Question: "Any good info on Lewy Body Dementia?"
Answer:
New actions:
- OVERVIEW(CTX, X) : Summarize all the essential information about X in input CTX
- SYMPTOMS(CTX, X) : Find information about all the symptoms of X in input CTX
- CONCAT(S1, S2, ...) : Concatenate the given inputs.

1. overview = OVERVIEW(CTX, "Lewy Body Dementia") : Summarize all the essential information about Lewy Body Dementia in input CTX
2. inherit = INHERITANCE_AND_CAUSES(CTX, "Lewy Body Dementia") : Find information about how Lewy Body Dementia is inherited, passed down, and its causes in the input CTX.
3. symptoms = SYMPTOMS(CTX, "Lewy Body Dementia") : Find information about all the symptoms of Lewy Body Dementia in input CTX.
4. help = SUPPORT(CTX, "Lewy Body Dementia") : Find support resources and groups for X in the input CTX.
5. ans = CONCAT(overview, inherit, symptoms, help) : Concatenate the given strings.

---

Question: "Possible treatments for Vitelliform Macular Dystrophy?"
Answer:
New actions:
- None

1. overview = OVERVIEW(CTX, "Vitelliform Macular Dystrophy") : Summarize all the essential information about Vitelliform Macular Dystrophy in input CTX
2. prognosis = PROGNOSIS_AND_RECOVERY(CTX, "Vitelliform Macular Dystrophy") : Find information about the prognosis, chances of recovery, and harmful effects for Vitelliform Macular Dystrophy in the input CTX.
3. treatment = TREATMENT_AND_EFFECTIVENESS(CTX, "Vitelliform Macular Dystrophy") : Find treatment options, effectiveness, and success of Vitelliform Macular Dystrophy in the input CTX.
4. ans = CONCAT(overview, prognosis, treatment) : Concatenate the given strings.
```

For a test question, "What blood tests confirm celiac disease," it generates this plan:

```
New actions:
- None

1. output_1 = DIAGNOSTIC_TESTS(CTX, "celiac disease") : Find diagnostic tests, screening methods, and testing methods for celiac disease given the input CTX.
2. output_2 = FILTER(output_1, "blood tests") : Filter the diagnostic tests to only include blood tests for celiac disease.
```

It's not a valid plan because FILTER isn't on the list of refined actions. Nonetheless, it's a promising start.

Plan Refinement

For our actual question on connections between the patient's medical condition and their lifestyle, PEARL generates this final plan after refinement:

```
New actions:
- LIFESTYLE_IMPACT(CTX, X) : Find information about how X is affecting the patient's lifestyle in the input CTX.
- LIFESTYLE_CHANGES(CTX, X) : Find recommendations for lifestyle changes the patient should make to manage X in the input CTX.

1. impact = LIFESTYLE_IMPACT(CTX, "medical condition") : Find information about how the medical condition is affecting the patient's lifestyle in the input CTX.
2. changes = LIFESTYLE_CHANGES(CTX, "medical condition") : Find recommendations for lifestyle changes the patient should make to manage the medical condition in the input CTX.
3. ans = CONCAT(impact, changes) : Concatenate the given strings.
```


Medical Report Question Answering Results

For a qualitative evaluation of the approach, we applied this lifestyle recommendation plan to the top five longest medical reports from the transcription dataset. These reports contain multiple sections for different medical specialties. We want the recommendation plan to extract relevant information from all sections.

Here are some of the results. Below is the longest and most complex report:

Report:
DATE OF INJURY : October 4, 2000, DATE OF EXAMINATION : September 5, 2003, EXAMINING PHYSICIAN : X Y, MD. Prior to the beginning of the examination, it is explained to the examinee that this examination is intended for evaluative purposes only, and that it is not intended to constitute a general medical examination. It is explained to the examinee that the traditional doctor-patient relationship does not apply to this examination, and that a written report will be provided to the agency requesting this examination. It has also been emphasized to the examinee that he should not attempt any physical activity beyond his tolerance, in order to avoid injury. **CHIEF COMPLAINT:** Aching and mid back pain. **HISTORY OF PRESENT INJURY:** Based upon the examinee's perspective, Mr. Abc is a 52-year-old self-employed, independent consultant for DEMILEE-USA. He is also a mechanical engineer. He reports that he was injured in a motor vehicle accident that occurred in October 4, 2000. At that time, he was employed as a purchasing agent for IBIKEN-USA. On the date of the motor vehicle accident, he was sitting in the right front passenger's seat, wearing seat and shoulder belt safety harnesses, in his 1996 or 1997 Volvo 850 Wagon automobile driven by his son. The vehicle was completely stopped and was "slammed from behind" by a van. The police officer, who responded to the accident, told Mr. Abc that the van was probably traveling at approximately 30 miles per hour at the time of impact. During the impact, Mr. Abc was restrained in the seat and did not contact the interior surface of the vehicle. He experienced immediate mid back pain. He states that the Volvo automobile sustained approximately \$4600 in damage. He was transported by an ambulance, secured by a cervical collar and backboard to the emergency department. An x-ray of the whole spine was obtained, and he was evaluated by a physician's assistant. He was told that it would be "okay to walk." He was prescribed pain pills and told to return for reevaluation if he experienced increasing pain. He returned to the Kaiser facility a few days later, and physical therapy was prescribed. Mr. Abc states that he was told that "these things can take a long time." He indicates that after one year he was no better. He then states that after two years he was no better and worried if the condition would never get better. He indicates he saw an independent physician, a general practitioner, and an MRI was ordered. The MRI study was completed at ABCD Hospital. Subsequently, Mr. Abc returned and was evaluated by a physiatrist. The physiatrist reexamined the original thoracic spine x-rays that were taken on October 4, 2000, and stated that he did not know why the radiologist did not originally observe vertebral compression fractures. Mr. Abc believes that he was told by the physiatrist that it involved either T6-T7 or T7-T8. Mr. Abc reports that the physiatrist told him that little could be done besides participation in core strengthening. Mr. Abc describes his current exercise regimen, consisting of cycling, and it was deemed to be adequate. He was told, however, by the physiatrist that he could also try a Pilates type of core exercise program. The physiatrist ordered a bone scan, and Mr. Abc is unsure of the results. He does not have a formal follow up scheduled with Kaiser, and is awaiting re-contact by the physiatrist. He denies any previous history of symptomatology or injuries involving his back. **CURRENT SYMPTOMS:** He reports that he has the same mid back pain that has been present since the original injury. It is located in the same area, the mid thoracic spine area. It is described as a pain and an ache and ranges from 3/10 to 6/10 in intensity, and the intensity varies, seeming to go in cycles. The pain has been staying constant. When I asked whether or not the pain had improved, he stated that he was unable to determine whether or not he had experienced improvement. He indicates that there may be less pain, or conversely, that he may have developed more of a tolerance for the pain. He further states that "I can power through it." "I have learned how to manage the pain, using exercise, stretching, and diversion techniques." It is primary limitation with regards to the back pain involves prolonged sitting. After approximately two hours of sitting, he has required to get up and move around, which results in diminishment of the pain. He indicates that prior to the motor vehicle accident, he could sit for significantly longer periods of time, 10 to 12 hours on a regular basis, and up to 20 hours, continuously, on an occasional basis. He has never experienced radiation of the pain from the mid thoracic spine, and he has never experienced radicular symptoms of radiation of pain into the extremities, numbness, tingling, or weakness. Again, aggravating activities include prolonged sitting, greater than approximately two hours. Alleviating activities include moving around, stretching, and exercising. Also, if he takes ibuprofen, it does seem to help with the back pain. He is not currently taking medications regularly, but list that he takes occasional ibuprofen when the pain is too persistent. He indicates that he received several physical therapy sessions for treatment, and was instructed in stretching and exercises. He has subsequently performed the prescribed stretching and exercises daily, for nearly three years. With regards to recreational activities, he states that he has not limited his activities due to his back pain. He denies bowel or bladder dysfunction. **FILES REVIEW:** October 4, 2000: An ambulance was dispatched to the scene of a motor vehicle accident on South and Parlow Road. The EMS crew arrived to find a 49-year-old male sitting in the front passenger seat of a vehicle that was damaged in a rear-end collision and appeared to have minimal damage. He was wearing a seatbelt and he denied loss of consciousness. He also denied a pertinent past medical history. They noted pain in the lower cervical area, mid thoracic and lumbar area. They placed him on a backboard and transported him to Medical Center. October 4, 2000: He was seen in the emergency department of Medical Center. The provider is described as "unknown." The history from the patient was that he was the passenger in the front seat of a car that was stopped and rear-ended. He stated that he did not exit the car because of pain in his upper back. He reported he had been wearing the seatbelt and harness at that time. He denied a history of back or neck injuries. He was examined on a board and had a cervical collar in place. He was complaining of mid back pain. He denied extremity weakness. Sensory examination was intact. There was no tenderness with palpation or flexion in the neck. The back was a little tender in the upper thoracic spine area without visible deformity. There were no marks on the back. His x-ray was described as "no acute bony process." Listed visit diagnosis was a sprain-thoracic, and he was prescribed hydrocodone/acetaminophen tablets and Motrin 800 mg tablets. October 4, 2000: During the visit, a Clinician's Report of Disability document was signed by Dr. M, authorizing time loss from October 4, 2000, through October 8, 2000. The document also advised no heavy lifting, pushing, pulling, or overhead work for two weeks. During this visit, a thoracic spine x-ray series, two views, was obtained and read by Dr. JR. The findings demonstrate no evidence of acute injury. No notable arthritic findings. The pedicles and paravertebral soft tissues appear unremarkable. November 21, 2000: An outpatient progress note was completed at Kaiser, and the clinician of record was Dr. H. The history obtained documents that Mr. Abc continued to experience the same pain that he first noted after the accident, described as a discomfort in the mid thoracic spine area. It was non-radiating and described as a tightness. He also reported that he was hearing clicking noises that he had not previously heard. He denied loss of strength in the arms. The physical examination revealed good strength and normal deep tendon reflexes in the arms. There was minimal tenderness over T4 through T8, in an approximate area.

The visit diagnosis listed was back pain. Also described in the assessment was residual pain from MVA, suspected bruised muscles. He was prescribed Motrin 800 mg tablets and an order was sent to physical therapy. Dr. N also documents that if the prescribed treatment measures were not effective, then he would suggest a referral to a physiatrist. Also, the doctor wanted him to discuss with physical therapy whether or not they thought that a chiropractor would be beneficial. December 4, 2000: He was seen at Kaiser for a physical therapy visit by Philippe Justel, physical therapist. The history obtained from Mr. ABC is that he was not improving. Symptoms described were located in the mid back, centrally. The examination revealed mild tenderness, centrally at T3-T8, with very poor segmental mobility. The posture was described as rigid T/S in flexion. Range of motion was described as within normal limits, without pain at the cervical spine and thoracic spine. The plan listed included two visits per week for two weeks, for mobilization. It is also noted that the physical therapist would contact the MD regarding a referral to a chiropractor. December 8, 2000: He was seen at Kaiser for a physical therapy visit by Mr. Justel. It was noted that the subjective category of the document revealed that there was no real change. It was noted that Mr. ABC tolerated the treatment well and that he was to see a chiropractor on Monday, December 11, 2000: He presented to the Chiropractic Wellness Center. There is a form titled 'Chiropractic Case History,' and it documents that Mr. ABC was involved in a motor vehicle accident, in which he was rear-ended in October. He has had mid back pain since that time. The pain is worsened with sitting, especially at a computer. The pain decreases when he changes positions, and sometimes when he walks. Mr. ABC reports that he occasionally takes 800 mg doses of ibuprofen. He reported he went to physical therapy treatment on two occasions, which helped for a few hours only. He did report that he had a previous history of transitory low back pain. During the visit, he completed a modified Oswestry Disability Questionnaire, and a WC/PI Subjective Complaint Form. He listed complaints of mid and low back pain of a sore and aching character. He rated the pain at grade 3-5/10, in intensity. He reported difficulty with sitting at a table, bending forward, or stooping. He reported that the pain was moderate and comes and goes. During the visit at the Chiropractic Wellness Center, a spinal examination form was completed. It documents palpation tenderness in the cervical, thoracic, and lumbar spine area and also palpation tenderness present in the suboccipital area, scalenes, and trapezia. Active cervical range of motion measured with goniometry reveals pain and restriction in all planes. Active thoracic range of motion measured with inclinometry revealed pain and restriction in rotation bilaterally. Active lumbosacral range of motion measured with inclinometry reveals pain with lumbar extension, right lateral flexion, and left lateral flexion. December 11, 2000: He received chiropractic manipulation treatment, and he was advised to return for further treatment at a frequency of twice a week. December 13, 2000: He returned to the Chiropractic Wellness Center to see Joe Smith, DC, and it is documented that his middle back was better. December 13, 2000: A personal injury patient history form is completed at the Chiropractic Wellness Center. Mr. ABC reported that on October 4, 2000, he was driving his 1996 Volvo 850 vehicle, wearing seat and shoulder belt safety harnesses, and completely stopped. He was rear-ended by a vehicle traveling at approximately 30 miles per hour. The impact threw him back into his seat, and he felt back pain and determined that it was not wise to move about. He reported approximate damage to his vehicle of \$4800. He reported continuing mid and low back pain, of a dull and semi-intense nature. He reported that he was an export company manager for IBIKEN-USA, and that he missed two full days of work, and missed 10-plus partial days of work. He stated that he was treated initially after the motor vehicle accident at Kaiser and received painkillers and ibuprofen, which relieved the pain temporarily. He specifically denied ever experiencing similar symptoms. December 26, 2000: A no-show was documented at the Chiropractic Wellness Center. April 5, 2001: He received treatment at the Chiropractic Wellness Center. He reported that two weeks previously, his mid back pain had worsened. April 12, 2001: He received chiropractic treatment at the Chiropractic Wellness Center. April 16, 2001: He did not show up for his chiropractic treatment. April 19, 2001: He did not show up for his chiropractic treatment. April 26, 2001: He received chiropractic manipulation treatment at the Chiropractic Wellness Center. He reported that his mid back pain increased with sitting at the computer. At the conclusion of this visit, he was advised to return to the clinic as needed. September 6, 2002: An MRI of the thoracic spine was completed at ABCD Hospital and read by Dr. RL, radiologist. Dr. D noted the presence of minor anterior compression of some mid thoracic vertebrae of indeterminate age, resulting in some increased kyphosis. Some of the mid thoracic discs demonstrate findings consistent with degenerative disc disease, without a significant posterior disc bulging or disc herniation. There are some vertebral end-plate abnormalities, consistent with small Schmorl's nodes, one on the superior aspect of T7, which is compressed anteriorly, and on the inferior aspect of T6. May 12, 2003: He was seen at the Outpatient Clinic by Dr. L, internal medicine specialist. He was there for a health screening examination, and listed that his only complaints are for psoriasis and chronic mid back pain, which have been present since a 2000 motor vehicle accident. Mr. ABC reported that an outside MRI showed compression fractures in the thoracic spine. The history further documents that Mr. ABC is an avid skier and volunteers on the ski patrol. The physical examination revealed that he was a middle-aged Caucasian male in no acute distress. The diagnosis listed from this visit is back pain and psoriasis. Dr. L documented that he spent one hour in the examination room with the patient discussing what was realistic and reasonable with regard to screening testing. Dr. L also stated that since Mr. ABC was experiencing chronic back pain, he advised him to see a physiatrist for evaluation. He was instructed to bring the MRI to the visit with that practitioner. June 10, 2003: He was seen at the Physiatry Clinic by Dr. R, physiatrist. The complaint listed is mid back pain. In the subjective portion of the chart note, Dr. R notes that Mr. ABC is involved in the import/export business, and that he is physically active in cycling, skiing, and gardening. He is referred by Dr. L because of persistent lower thoracic pain, following a motor vehicle accident, on October 4, 2000. Mr. ABC told Dr. R that he was the restrained passenger of a vehicle that was rear-ended at a moderate speed. He stated that he experienced immediate discomfort in his thoracic spine area without radiation. He further stated that thoracic spine x-rays were obtained at the Sunnyside Emergency Room and read as normal. It is noted that Mr. ABC was treated conservatively and then referred to physical therapy where he had a number of visits in late of 2002 and early 2003. No further chart entries were documented about the back problem until Mr. ABC complained to Dr. L that he still had ongoing thoracic spine pain during a visit the previous month. He obtained an MRI, out of pocket, at ABCD Hospital and stated that he paid \$1100 for it. Dr. R asked to see the MRI and was told by Mr. ABC that he would have to reimburse or pay him \$1100 first. He then told the doctor that the interpretation was that he had a T7 and T8 compression fracture. Mr. ABC reported his improvement at about 20%, compared to how he felt immediately after the accident. He described that his only symptoms are an aching pain that occurs after sitting for four to five hours. If he takes a break from sitting and walks around, his symptoms resolve. He is noted to be able to bike, ski, and be active in his garden without any symptoms at all. He denied upper extremity radicular symptoms. He denied lower extremity weakness or discoordination. He also denied bowel or

bladder control or sensation issues. Dr. R noted that Mr. ABC was hostile about the Kaiser health plan and was quite uncommunicative, only reluctantly revealing his history. The physical examination revealed that he moved about the examination room without difficulty and exhibited normal lumbosacral range of motion. There was normal thoracic spine motion with good chest expansion. Neurovascular examination of the upper extremities was recorded as normal. There was no spasticity in the lower extremities. There was no tenderness to palpation or percussion up and down the thoracic spine. Dr. R reviewed the thoracic spine films and noted the presence of "a little compression of what appears to be T7 and T8 on the lateral view." Dr. R observed that this was not noted on the original x-ray interpretation. He further stated that the MRI, as noted above, was not available for review. Dr. R assessed that Mr. ABC was experiencing minimal thoracic spine complaints that probably related to the motor vehicle accident three years previously. The doctor further stated that "the patient's symptoms are so mild as to almost not warrant intervention." He discussed the need to make sure that Mr. ABC's workstation was ergonomic and that Mr. ABC could pursue core strengthening. He further recommended that Mr. ABC look into participation in a Pilates class. Mr. ABC was insistent, so Dr. R made plans to order a bone scan to further discriminate the etiology of his symptoms. He advised Mr. ABC that the bone scan results would probably not change treatment. As a result of this visit, Dr. R diagnosed thoracic spine pain (724.1) and ordered a bone scan study.

The lifestyle recommendation plan for it returns this comprehensive answer:

Lifestyle Answer:

The medical condition of mid back pain is affecting the patient's lifestyle in several ways. The patient reports that the pain has been present since the original injury and is described as a pain and ache in the mid thoracic spine area. The intensity of the pain ranges from 3/10 to 6/10 and varies in cycles. The pain has been staying constant and the patient is unsure if there has been any improvement or if he has developed a tolerance for the pain. The patient has learned how to manage the pain using exercise, stretching, and diversion techniques, but it still limits his activities involving prolonged sitting. After approximately two hours of sitting, he experiences increased pain and needs to get up and move around to alleviate it. Prior to the motor vehicle accident, he was able to sit for significantly longer periods of time, up to 10 to 12 hours on a regular basis and up to 20 hours continuously on occasion. The patient also reports that he has not limited his recreational activities due to his back pain. Overall, the mid back pain affects the patient's ability to sit for long periods of time and requires him to take breaks to alleviate the pain.

To manage the patient's mid back pain, there are several lifestyle changes that could be recommended:

1. Avoiding prolonged sitting: The patient should try to limit the amount of time spent sitting, especially for more than two hours at a time. Taking breaks to stand up, stretch, and move around can help alleviate the pain.
2. Core strengthening exercises: The physiatrist suggested that the patient participate in core strengthening exercises. This could include activities such as Pilates or other exercises that focus on strengthening the muscles in the abdomen, back, and pelvis. Regularly engaging in these exercises can help improve posture and provide support to the mid back area.
3. Ergonomic workstation setup: The physiatrist mentioned the importance of ensuring that the patient's workstation is ergonomic. This means that the desk, chair, and computer setup should be adjusted to promote good posture and reduce strain on the back. This may involve adjusting the height of the chair, using a lumbar support cushion, and positioning the computer monitor at eye level.
4. Regular exercise and stretching: The patient reported that exercise and stretching have helped manage the pain. Continuing with a regular exercise regimen, such as cycling, can help maintain overall fitness and flexibility. Additionally, incorporating specific stretches for the mid back area can help alleviate tension and improve mobility.
5. Pain management techniques: The patient mentioned using ibuprofen occasionally to help with the back pain. This can be continued as needed, but it is important to follow the recommended dosage and consult with a healthcare professional if the pain persists or worsens.

It is important for the patient to follow up with the physiatrist and discuss the results of the bone scan. The physiatrist can provide further guidance on managing the mid back pain and recommend any additional lifestyle changes or treatments that may be necessary.

Notice how the plan includes information from all sections of the report.

The next longest report contains complex information and connections:

Report:
HISTORY OF PRESENT ILLNESS: The patient is a 79-year-old right-handed man who reports that approximately one and a half years ago, he fell down while walking in the living room from the bedroom. At that time, he reports both legs gave away on him and he fell. He reported that he had some lightheadedness just before he fell and was slightly confused, but was aware of what was happening around him. He was able to get up shortly after falling and according to the patient and his son, subsequently returned back to normal. He was then well until the 3rd of July 2008 when his legs again gave way on him. This was not preceded by lightheadedness. He was rushed to the hospital and was found to have pneumonia, and the fall was blamed on the pneumonia. He started using a walker from that time, prior to that he was able to walk approximately two miles per day. He again had a fall in August of 2008 after his legs gave way. Again, there was no lightheadedness associated with this. He was again found to have pneumonia and again was admitted to hospital after which he went to rehabilitation and was able to use his walker again after this. He did not, however, return to the pre-July baseline. In October of 2008, after another fall, he was found to have pneumonia again and shingles. He is currently in a Chronic Rehabilitation Unit. He cannot use a walker and uses a wheelchair for everything. He states that his hands have been numb, involving all the fingers of both hands for the past three weeks. He is also losing muscle bulk in his hands and has noticed some general weakness of his hands. He does, however, note that strength in his hands has not been normal since July 2008, but it is clearly getting worse. He has been aware of some fasciculations in his legs starting in August 2008, these are present both in the lower legs and the thighs. He does not report any cramps, problems with swallowing or problems with breathing. He reports that he has had constipation alternating with diarrhea, although there has been no loss of control of either his bowel or bladder. He has had some problems with blood pressure drops, and does feel presyncopal when he stands. He also reports that he has no feeling in his feet, and that his feet feel like sponges. This has been present for about nine months. He has also lost joint position sense in his feet for approximately nine months. **PAST MEDICAL HISTORY:** 1. Pneumonia. He has had recurrent episodes of pneumonia, which started at approximately age 20. These have been treated repeatedly over the years, and on average he has tended to have an episode of pneumonia once every five years, although this has been far more frequent in the past year. He is usually treated with antibiotics and then discharged. There is no known history of bronchiectasis, inherited lung disease or another chronic pulmonary cause for the repeated pneumonia. 2. He has had a catheter placed for urinary retention, his urologist has told him that he thinks that this may be due to prostate enlargement. The patient does not have any history of diabetes and does not report any other medical problems. He has lost approximately 38 pounds in the past month. 3. He had an appendectomy in the 1940s. 4. He had an ankle resection in 1975. **SOCIAL HISTORY:** The patient stopped smoking 27 years ago, he smoked approximately two packs a day with combined cigarettes and cigars. He has not smoked for the past 27 years. He hardly ever uses alcohol. He is currently retired. **FAMILY HISTORY:** There is no family history of neuropathy, pes cavus, foot deformities, or neuromuscular diseases. His aunt has a history of type II diabetes. **CURRENT MEDICATIONS:** Fludrocortisone 0.1 mg p.o. q.d., midodrine 5 mg p.o. q.i.d., Cymbalta 30 mg p.o. per day, Pirosec 20 mg p.o. per day, Lortab 10 mg p.o. per day, Amoxil 500 mg p.o. per day, vitamin B12 1000 mcg weekly, vitamin D 1000 units per day, Metamucil p.r.n., enteric-coated aspirin once a day, Colace 200 mg p.o. q.d., Serenol three tablets p.o. p.r.n., Reglan 10 mg p.o. q.6h., Xanax 0.25 mg p.o. q.8h. p.r.n., Ambien 5 mg p.o. q.h.s. p.r.n. and Dilaudid 2 mg tablets p.o. q.3h. p.r.n., Protonix 40 mg per day, and Megace 400 mg per day. **ALLERGIES:** He has no medication or food allergies. **REVIEW OF SYSTEMS:** Please see the health questionnaire and clinical notes from today. **GENERAL PHYSICAL EXAMINATION:** **VITAL SIGNS:** BP was 137/60, P was 89, and his weight could not be measured because he was in a wheelchair. His pain score was 0. **APPEARANCE:** No acute distress. He is pleasant and well-groomed. **HEENT:** Atraumatic, normocephalic. No carotid bruits appreciated. **LUNGS:** There were few coarse crackles in both lung bases. **CARDIOVASCULAR:** Revealed a normal first and second heart sound, with no third or fourth heart sound and no murmurs. The pulse was regular and of normal volume. **ABDOMEN:** Soft with no masses and normal bowel sounds. There were no carotid bruits. **EXTREMITIES:** No contractures appreciated. **NEUROLOGICAL EXAM:** **MSE:** His orientation, language, calculations, 100-7 tests were all normal. There was atrophy and fasciculations in both the arms and legs. **CRANIAL NERVES:** Cranial nerve examination was normal with the exception that there was some mild atrophy of his tongue and possible fasciculations. His palatal movement was normal and gag reflex was normal. **MOTOR:** Strength was decreased in all muscle groups as follows: Deltoid 4/4, biceps 4+/4+, triceps 5/5, wrist extensors 4+/4+, finger extensors 4-/4-, finger flexors 4-/4-, interossei 4-/4-, hip flexors 4+/4+, hip extensors 4+/4+, knee extensors 4/4, and knee flexors 4/4. Foot dorsiflexion, plantar flexion, eversion, toe extension and toe flexion was all 0 to 1. There was atrophy in both hands and general atrophy of the lower limb muscles. The feet were both cold and showed dystrophic features. Fasciculations were present mainly in the hands. There was evidence of dysmetria and past pointing in the left hand. **REFLEXES:** Reflexes were 0 in all sites in the arms and legs. The jaw reflex was 2+. Vibration was severely decreased at the elbow and wrist and was absent in the fingers. Vibration was absent in the toes and ankle bilaterally and was severely decreased at the knee. Joint position sense was absent in the toes and severely decreased in the fingers. Pin perception was absent in the feet and was decreased to the upper thighs. Pin was decreased or absent in the fingers and decreased above the elbows. The same distribution of sensory loss was found with monofilament testing. **COORDINATION:** Coordination was barely normal in the right hand. Rapid alternating movements were decreased in the left hand greater than the right hand. The patient was unable to stand and therefore gait, Romberg's test and balance could not be assessed. **DIAGNOSTIC STUDIES:** Previous diagnostic studies and patient reports. There were extensive patient reports, all of which were reviewed. A previous x-ray study of the lateral chest performed in October 2008 showed poor inspiration with basilar atelectasis and an infiltrate. An x-ray of the cervical, thoracic and lumbar spine showed some evidence of lumbar spinal stenosis. A CTA of the neck with and without contrast performed in November 2008 showed minor stenosis in the left carotid, a mild hard and soft plaque in the right carotid with approximately 55% stenosis. The posterior circulation showed a slightly dominant right vertebral artery with no stenosis. There was no significant stenosis, but there was minor extracranial stenosis noted. An MRI of the brain with and without contrast performed in November 2008 showed no evidence of an acute infarct, major vascular occlusion, and no abnormal enhancement with gadolinium administration. There was also no significant sinusitis or mastoiditis. This was an essentially normal brain MRI. A CBC performed in January 2009 showed an elevated white cell count of 11.3, a low red cell count of 3.43, elevated MCH of 32.4 and the rest of the study was normal. An electrolyte study performed in January 2009 showed a sodium which was low at 127, a calcium which was low at 8.3, and a low protein of 5.2 and albumin of 3.1. The glucose was 86. TSH performed in

January 2009 was 1.57, which is within the normal range. Vitamin B12 was greater than a 1000, which is normal and the folate was 18.2, which was normal. A myocardial stress study performed in December 2008 showed normal myocardial perfusion with Persantine Cardioline SPECT. The ECG was non-diagnostic. There was normal regional wall motion of the left ventricle. The left ventricular ejection fraction was 68%, which is within the normal range for males. A CT of the lumbar spine without contrast performed in December 2008 showed a broad-based disc bulge at L1-L2, L2-L3, L3-L4 and L4-L5. At L5-S1, in addition to the broad-based disc bulge, there was also an osteophyte complex and evidence of flavum hypertrophy without canal stenosis. There was severe bilateral neural foraminal stenosis at L5-S1 and moderate neural foraminal stenosis at L1-L4. An echocardiogram was performed in November 2008 and showed mild left atrial enlargement, normal left ventricular systolic function, mild concentric left ventricular hypertrophy, sclerotic degenerative changes in the aortic and mitral apparatus, mild mitral regurgitation, mild tricuspid regurgitation and mild to moderate aortic regurgitation. **DIAGNOSTIC IMPRESSION:** The patient presents with a severe neuropathy with marked large fiber sensory as well as motor findings. He is diffusely weak as well as atrophic in all muscle groups both in his upper and lower extremities, although he is disproportionately weak in his lower extremities. His proprioceptive and vibratory loss is severe in both the distal upper and lower extremities, signifying that he either has a severe sensory neuropathy or has involvement of the dorsal root ganglia. According to the history, which was carefully checked, the initial onset of these symptoms goes back one and a half years, although there has only been significant progression in his condition since July 2008. As indicated below, further diagnostic studies including a detailed nerve conduction and EMG test today showed evidence of a severe sensory, motor, and axonal neuropathy and in addition there was evidence of a diffuse polyradiculopathy. There was no involvement of the tongue on EMG. The laboratory testing as indicated below failed to show a specific cause for the neuropathy. We are still, however, waiting for the paraneoplastic antibodies, which were sent out lab to the Mayo Clinic. This type of very severe sensorimotor neuropathy with significant proprioceptive loss may be seen in several conditions including peripheral nerve vasculitis due to a variety of disorders such as SLE, Sjogren's, rheumatoid arthritis, and mixed connective tissue disease. In addition, it may also be seen with certain toxins, particularly chemotherapeutic agents. The patient did not receive any of these. It may also be seen as part of a paraneoplastic syndrome. Although the patient does not have any specific clinical symptoms of a cancer, it is noted that he has had an 18-pound weight loss in the past month and does have a remote history of smoking. We have requested that he obtain a CT of his chest, abdomen and pelvis while he is in Acute Rehabilitation. The verbal reports of these possibly did not show any evidence of a cancer. We did also request that he obtain a gallium scan to see if there was any evidence of an unsuspected neoplasm. The patient did undergo a nerve and muscle biopsy, this was a radial nerve and biceps muscle biopsy from the left arm. This showed evidence of severe axonal loss. There was no evidence of a vasculitis. The vessels did show some mild intimal changes that would be consistent with atherosclerosis. There were a few perivascular changes; however, there was no clear evidence of a necrotizing vasculitis even on multiple sections. The muscle biopsy showed severe muscle fiber atrophy, with evidence of fiber grouping. Again, there was no evidence of inflammation or vasculitis. Evaluation so far has also shown no evidence of an amyloid neuropathy, no evidence of a monoclonal gammopathy, of sarcoidosis, and again there is no past history of a significant toxin or infective cause for the neuropathy. Specifically, there is no history of HIV exposure. We would await the results of the gallium scan and of the paraneoplastic antibodies to see if these are helpful in making a diagnosis. At this point, because of the severity and the axonal nature of the neuropathy, there is no specific therapy that will reverse the course of the illness, unless we find a specific etiology that can be stopped or reversed. I have discussed these issues at length with the patient and with his son. We also addressed whether or not there might be a previously undiagnosed inherited neuropathy. I think this is unlikely given the short history and the rapid progression of the disorder. There is also no family history that we can detect a neuropathy, and the patient does not have the typical phenotype for a chronic inherited neuropathy such as Charcot-Marie-Tooth disease type 2. However, since I have only seen the patient on one occasion and do not know what his previous examination showed two years ago, I cannot be certain that there may not have been the presence of a neuropathy preceding this. **PLAN:** 1. Nerve conduction and EMG will be performed today. The results were indicated above. 2. The following laboratory studies were requested including electrolytes, CBC, thyroid function tests, B12, ANA, C-reactive protein, complement, cryoglobulins, double-stranded DNA antibodies, folate level, hemoglobin A1c, immunofixation electrophoresis, P-ANCA, C-ANCA, protein electrophoresis, rheumatoid factor, paraneoplastic antibody studies requested from the Mayo Clinic, B12. These studies showed minor changes, which included a low sodium level of 129 as previously noted, a low creatinine of 0.74, low calcium of 8.6, low total protein of 5.7. The B12 was greater than 2000. The immunoelectrophoresis, ANA, double-stranded DNA, ANCA, hemoglobin A1c, folate, cryoglobulins, complement, C-reactive protein were all normal or negative. The B12 level was greater than 2000. Liver function tests were normal. The glucose was 90. ESR was 10. Hemoglobin A1c was 5.5. 3. A left radial sensory and left biceps biopsy were requested and have been performed and interpreted as indicated above. 4. CT of chest, abdomen and pelvis. 5. Whole body gallium scan for evidence of an underlying neoplasm. 6. The patient will go to the Rehabilitation Facility for Acute Rehabilitation and Training. 7. We have not made any changes to his medication. He does have some mild orthostatic changes; however, he is adequately controlled with midodrine at a dose of 2.5 mg three times a day as needed up to 5 mg four times a day. Usually, he uses a lower dose of 2.5 three times a day to 5 mg three times a day. 8. Followup will be as determined by the family.

The lifestyle plan for it is shown below:

Lifestyle Answer:

The medical condition, which is a severe neuropathy with marked large fiber sensory and motor findings, is significantly impacting the patient's lifestyle. The patient is currently in a Chronic Rehabilitation Unit and is unable to use a walker, relying on a wheelchair for all activities. Prior to the onset of the condition, the patient was able to walk approximately two miles per day. The loss of mobility has greatly limited the patient's independence and ability to engage in physical activities.

Additionally, the patient reports numbness and loss of feeling in his feet, which has been present for about nine months. This sensory loss in the feet, along with the general weakness and atrophy in the hands, has affected the patient's ability to perform fine motor tasks. He has noticed muscle bulk loss in his hands and weakness, making it difficult to perform activities that require dexterity and strength.

The patient also reports constipation alternating with diarrhea, although there has been no loss of control of his bowel or bladder. This gastrointestinal symptom may be related to the underlying medical condition and can impact the patient's daily routine and overall comfort.

Furthermore, the patient experiences blood pressure drops and presyncopal symptoms when standing, indicating orthostatic hypotension. This can lead to dizziness and lightheadedness, potentially affecting the patient's ability to stand or perform activities that require being upright for extended periods.

Overall, the severe neuropathy has significantly impacted the patient's mobility, fine motor skills, gastrointestinal function, and cardiovascular stability, resulting in a significant decrease in his overall quality of life and independence.

The patient in the given history of present illness has a severe neuropathy with marked large fiber sensory and motor findings. The specific cause of the neuropathy has not been determined yet, but there are some lifestyle changes that can be recommended to manage the condition:

1. Smoking cessation: Although the patient stopped smoking 27 years ago, it is important to emphasize the importance of maintaining a smoke-free lifestyle. Smoking can have detrimental effects on the nervous system and overall health, so it is crucial to avoid exposure to tobacco smoke.
2. Regular exercise: Engaging in regular physical activity can help improve overall muscle strength and mobility. It is important to consult with a healthcare professional or physical therapist to determine the appropriate exercises and intensity level for the patient's condition.
3. Balanced diet: A well-balanced diet rich in nutrients can support overall health and potentially aid in nerve regeneration. Including a variety of fruits, vegetables, whole grains, lean proteins, and healthy fats can provide essential vitamins and minerals necessary for nerve health.
4. Adequate hydration: Staying hydrated is important for overall health and can help maintain proper nerve function. Encourage the patient to drink an adequate amount of water throughout the day.
5. Fall prevention: Given the patient's history of falls, it is important to take measures to prevent future falls. This may include removing tripping hazards in the living environment, using assistive devices such as handrails or grab bars, and wearing appropriate footwear for stability.
6. Stress management: Chronic illness can often lead to increased stress levels. Encourage the patient to engage in stress-reducing activities such as meditation, deep breathing exercises, or pursuing hobbies and interests that bring joy and relaxation.
7. Regular follow-up and adherence to treatment plan: It is important for the patient to attend regular follow-up appointments with healthcare professionals to monitor the progression of the condition and adjust the treatment plan as needed. Adherence to prescribed medications and therapies is crucial for managing symptoms and potentially slowing down the progression of the neuropathy.

It is important to note that these lifestyle changes are general recommendations and may need to be tailored to the specific needs and limitations of the patient. Consulting with healthcare professionals, such as neurologists or physical therapists, can provide more personalized guidance and recommendations.

Again, the answer is comprehensive with information from all sections of the report.

These results show that PEARL can be easily adapted for multiple domains.

PEARL Overcomes Many LLM Drawbacks

In this article, you saw how PEARL can dynamically generate pipelines to solve complex tasks. In addition, it does so using just prompts and few-shot examples without requiring any fine-tuning. This is a capability that was previously not possible with other prompting strategies or task-planning techniques. [Contact us](#) to discover how you can apply PEARL for your difficult business problems.

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