第 1 讲: 测试

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评阅:		评分:	

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这是适用于问题求解作业的 Typst 模板,
也可用于其他类型的作业与报告等。
该模板仍在进行测试中,
请谨慎使用。

1 作业 (必做部分)

Problem 1 (AC 1.2-3)

Solution:

1 Lorem ipsum dolor.

a) when $\min(\|\boldsymbol{x}\|_2)$, $\boldsymbol{x} = \boldsymbol{x}^*$ is the solution to the problem, which is $x^* = \begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix}$

b) We have a matrix $\boldsymbol{A} = \begin{pmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 0 \end{pmatrix}$, the projection operator is

$$\boldsymbol{P} = \boldsymbol{A}(\boldsymbol{A}^T A)^{-1}\boldsymbol{A}^T = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} & 0 \\ \frac{1}{2} & \frac{1}{2} & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

hence,

$$\boldsymbol{x}^* = \boldsymbol{P}\boldsymbol{v} = \begin{pmatrix} \frac{1}{2} \\ \frac{1}{2} \\ 1 \end{pmatrix}.$$

2 Lorem ipsum dolor sit amet.

c) We have a matrix $\boldsymbol{A} = \begin{pmatrix} 1 & -1 \\ -1 & 1 \\ 2 & 2 \end{pmatrix}$, the projection operator is

$$\boldsymbol{P} = \boldsymbol{A}(\boldsymbol{A}^T A)^{-1}\boldsymbol{A}^T = \begin{pmatrix} \frac{1}{2} & -\frac{1}{2} & 0 \\ -\frac{1}{2} & \frac{1}{2} & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

hence,

$$\boldsymbol{x}^* = \boldsymbol{P}\boldsymbol{v} = \begin{pmatrix} \frac{1}{2} \\ -\frac{1}{2} \\ 0 \end{pmatrix}.$$

Problem 2

Solution:

1. we know that:

$$\operatorname{prox}_{\varphi}(z) = \arg\min_{x\in\mathbb{R}}\left\{\frac{1}{2}\|x - z\|^2 + \phi(x - c)\right\}.$$

let $x' = x - c$

$$\mathrm{prox}_\varphi(z) = \arg\min_{x\in\mathbb{R}}\left\{\frac{1}{2}\|x' - (z-c)\|^2 + \phi(x'+c-c)\right\} + c = \mathrm{prox}_\phi(z-c) + c.$$

2. if we want to $f(x) = \frac{1}{2}\|x-z\|^2 + \phi(x)$ to be minimized, we need to find the x that makes the derivative of the function equal to zero.

   we know

$$\partial f(x) = \begin{cases} x - z + \lambda \text{ when } \ x > 0 \\ [x-z-\lambda, x-z+\lambda] \text{ when } x = 0 \\ x - z - \lambda \text{ when } x < 0 \end{cases}$$

   . Hence, let

$$\partial f(x) = 0$$

   , we have

$$\mathrm{prox}_{\phi(z)} = x^* = \begin{cases} z - \lambda \text{ when } \ z > \lambda \\ [z-\lambda, z+\lambda] \text{ when } z \in [-\lambda, \lambda]. \\ z + \lambda \text{ when } z < -\lambda \end{cases}$$

3. if $\varphi(x) = \lambda|x-c|$, where $c \in \mathbb{R}$ and $\lambda > 0$. Use the result from part a.

$$\mathrm{prox}_{\varphi(z)} = \mathrm{prox}_{\phi(z-c)} + c = \begin{cases} z - \lambda \text{ when } \ z > \lambda + c \\ [z-\lambda, z+\lambda] \text{ when } z \in [-\lambda + c, \lambda + c] \\ z + \lambda \text{ when } z < -\lambda + c \end{cases}$$

Problem 3

Solution:

1. If we take the derivative of $\frac{1}{2}\left\|\boldsymbol{x} - \boldsymbol{x}^{t-1}\right\|^2 + \gamma g(\boldsymbol{x})$, we have

$$\boldsymbol{x}^{\boldsymbol{t}} = \mathrm{prox}_{\gamma g}(\boldsymbol{x}^{t-1}) = \boldsymbol{x}^{t-1} - \gamma\nabla g(\boldsymbol{x}^{\boldsymbol{t}})$$

2. By the convexity of g, we know that $g(\boldsymbol{x}^t) + \nabla g(\boldsymbol{x}^t)^T(\boldsymbol{x}^{t-1} - \boldsymbol{x}^t) \leq g(\boldsymbol{x}^{\boldsymbol{t-1}})$. Hence, we have

$$g(\boldsymbol{x}^t) \leq g(\boldsymbol{x}^{\boldsymbol{t-1}}) - \nabla g(\boldsymbol{x}^t)^T(\boldsymbol{x}^{t-1} - \boldsymbol{x}^t) = g(\boldsymbol{x}^{\boldsymbol{t-1}}) - \gamma\nabla\left\|g(\boldsymbol{x}^t)\right\|_2^2$$

3. because $\boldsymbol{x}^{\boldsymbol{t}} = \boldsymbol{x}^{t-1} - \gamma\nabla g(\boldsymbol{x}^{\boldsymbol{t}})$ which is a gradient descent method, so

$$-\infty < g(\boldsymbol{x}^t) \leq g(\boldsymbol{x}^{t-1})$$

   and we have

$$g(\boldsymbol{x}^t) \leq g(\boldsymbol{x}^{\boldsymbol{t-1}}) - \gamma\nabla\left\|g(\boldsymbol{x}^t)\right\|_2^2$$

   hence

$$0 \leq \gamma\nabla\left\|g(\boldsymbol{x}^t)\right\|_2^2 \leq 0$$

if

$$t \to +\infty$$

Problem 4 (ST 5.5-5)

Proof:

1. because

$$\partial f(\boldsymbol{x}) = \{\boldsymbol{v} \in \mathbb{R}^n : f(\boldsymbol{y}) \geq f(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\}$$

   if $g(\boldsymbol{x}) = \theta f(\boldsymbol{x})$,

$$\partial g(\boldsymbol{x}) = \{\boldsymbol{v} \in \mathbb{R}^n : g(\boldsymbol{y}) \geq g(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\}$$

$$\partial g(\boldsymbol{x}) = \{\boldsymbol{v} \in \mathbb{R}^n : \theta f(\boldsymbol{y}) \geq \theta f(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\}$$

$$\partial g(\boldsymbol{x}) = \left\{\boldsymbol{v} \in \mathbb{R}^n : f(\boldsymbol{y}) \geq f(\boldsymbol{x}) + \frac{\boldsymbol{v}^T}{\theta}(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\right\}$$

$$\partial g(\boldsymbol{x}) = \theta\{\boldsymbol{v} \in \mathbb{R}^n : f(\boldsymbol{y}) \geq f(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\} = \theta \partial f(\boldsymbol{x})$$

2.

$$\partial h(\boldsymbol{x}) = \{\boldsymbol{v} \in \mathbb{R}^n : f(\boldsymbol{y}) + g(\boldsymbol{y}) \geq f(\boldsymbol{x}) + g(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n\}$$

   all of the elements that satisfy

$$f(\boldsymbol{y}) \geq f(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n$$

   and

$$g(\boldsymbol{y}) \geq g(\boldsymbol{x}) + \boldsymbol{v}^T(\boldsymbol{y} - \boldsymbol{x}), \forall \boldsymbol{y} \in \mathbb{R}^n$$

   are in the set

$$\partial h(\boldsymbol{x})$$

   hence

$$\partial f(\boldsymbol{x}) + \partial g(\boldsymbol{x}) \subseteq \partial h(\boldsymbol{x})$$

3. we know that

$$\partial \|x\|_1 = \begin{cases} 1 \text{ when } \ x > 0 \\ [-1, 1] \text{ when } x = 0 \\ -1 \text{ when } x < 0 \end{cases}$$

   .

   hence $\operatorname{sgn}(x) \in \partial \|x\|_1$.

Problem 5

Solution:

中文排印测试：

Here’s a test sentence, “I can eat glass, it does not hurt me.”

这是一条测试语句：“我能吞下玻璃而不伤身体。”

這是一條測試語句：「我能吞下玻璃而不傷身體。」

默認使用 “Noto Serif”, “IBM Plex Serif” 字形，並且設置語言為 “zh”，地區為 “cn”。

目前的效果是，當引號"兩邊有 CJK 字符，引號將以半角顯示“，否則正常顯示英文引號。

測試：“中文引號”, “quotation marks”.

Problem 6

Solution:

This a test for code blocks.

For rust:

rust

```rust
pub fn main() {
    println!("Hello, world!");
}
```

Highlight some lines:

python

```python
import numpy as np

def fibonaci(n):
  if n <= 1:
    return n
  else:
    return(fibonaci(n-1) + fibonaci(n-2))

fibonaci(10)
```

Commenting some lines and adding header and footer:

python

This is a test for zebraw.

```python
import numpy as np

def fibonaci(n):
  if n <= 1:
    return n
  else:
    return(fibonaci(n-1) + fibonaci(n-2))
```

> $f_n = f_{n-1} + f_{n-2}$

```

fibonaci(10)
```

```
End of the test.
```

Then pseudocodes.

Algorithm 1: The Euclidean algorithm

input: integers a and b
output: greatest common divisor of a and b
1 **while** $a \neq b$ **do**
2   **if** $a > b$ **then**
3         $a \leftarrow a - b$
4   **else**
5         $b \leftarrow b - a$ ▷ comment test
6   **end** ▷ another comment test
7 **end**
8 **return** a

Algorithm 1

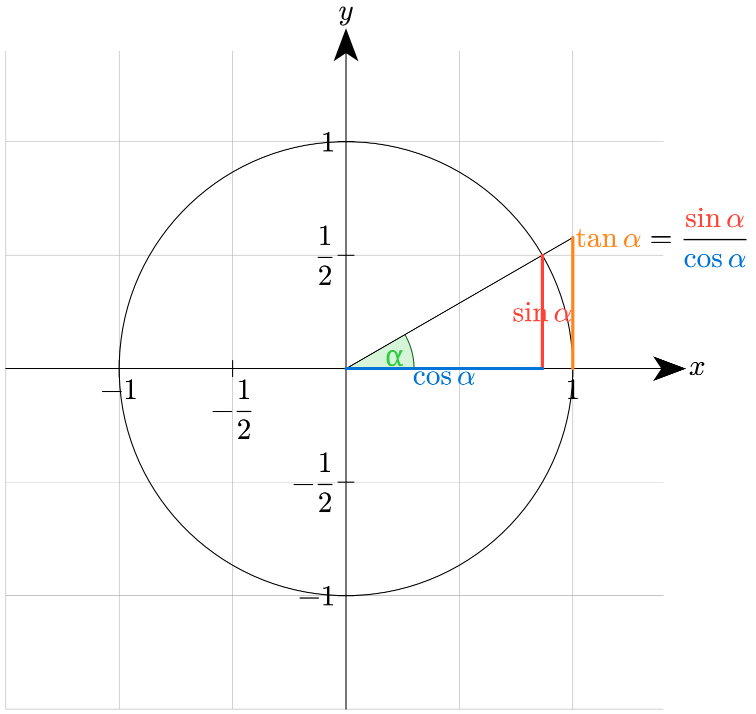
In Line 1, we have a while loop.

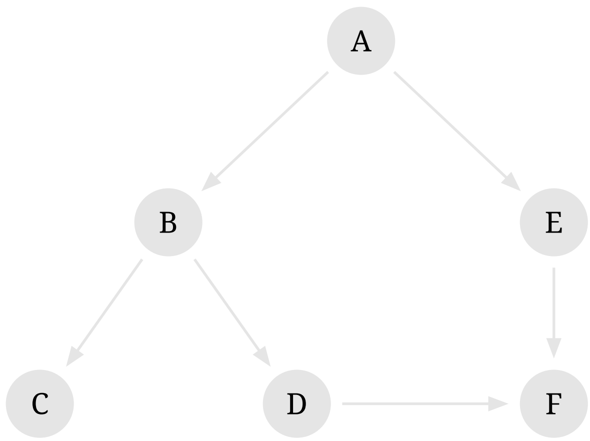
The algorithm figure's breakable.

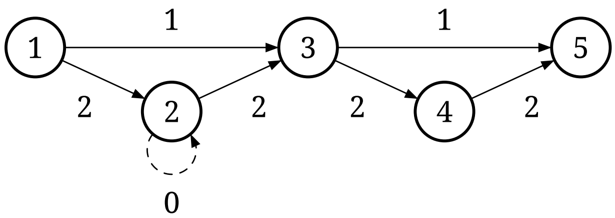
Problem 7 ()

This is a test for CeTZ.

Solution:







2 作业 (选做部分)

Problem 1 (EoSD 9961)

How to pass 「レッドマジック」?

Solution:

Practice more.