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| Weekly Research Report | | | |
| Name | Aiyung | Duration | 2025/01/09 ~ 2025/01/15 |
| Date | 2025/01/15 | (week 18) | |

* Bring your research notebook every time for cross check when present your weekly report.
* The weekly report should be written over 1 page.

1. Brief title of this report (本報告主題)

1.1 無網格法收斂性測試

1.2 台日數學會Abstract

1. Research issue address at … (研究過程中發現的問題)

在驗證可用性之前，需要驗證**收斂性**與**一致性**。

* 一致性(Consistency): 能夠正確地模擬基本解。（給定解析解作為邊界條件）
* 收斂性(Convergence): 隨著節點密集化，數值解能收斂到正確的解。（穩定性）

1. Method or possible solutions (提出可能的解決方法)

數值方法中使用下列範數分析誤差收斂性：

|  |  |  |
| --- | --- | --- |
| norm |  |  |
| norm |  |  |

一張含有 文字, 圖表, 螢幕擷取畫面, 行 的圖片

自動產生的描述

圖 1理想之Convergence rate plot

當, norm 應減小為原來的； norm 應減小為原來的。

其中是平均節點間距（有限元網格大小）；代表 order completeness.（有限元中的p階單元）

1. Outcomes and new derivative problems (因應該方法產生的結果，及或衍生的新問題)

積分結果無法正確收斂。

|  |  |
| --- | --- |
| 一張含有 文字, 螢幕擷取畫面, 行, 圖表 的圖片  自動產生的描述 | 一張含有 文字, 螢幕擷取畫面, 行, 圖表 的圖片  自動產生的描述 |
| (a) error norm | (b) Energy error norm |

圖 1目前實作的數值穩定方法與其Convergence rate

其中Without為無施加任何數值積分穩定方法；NSNI為naturally stabilized nodal integration；MSCNI為Least-squares type stabilization（又稱M-type Stabilization）。

可以看到在 norm中三者無明顯區別，而在 norm中看似有改善但藍色線仍沒有達到理想的收斂速率（約，）。

1. Conclusion & Discussions (小結與討論)

此結果看似穩定卻帶有不完備的成分，個人認為比較有可能是哪個地方程式寫錯。

比較糟的情況是數學公式轉程式時推導錯誤。

1. Plan for next week (下周預期工作內容，提出可能解決本周問題的幾種規劃)

先進行code review看問題出在哪裡。

**A variationally consistent simulation for orthognathic surgical planning in soft tissue deformation**

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Predicting post-operative outcomes remains a significant challenge in surgical planning due to the inherent complexities of human anatomy and the large deformations exhibited by soft tissue, making it difficult to achieve cost-effective and patient-specific simulations.

~~Current clinical practices~~ often rely on simplified methods such as linear interpolation, mass-spring models, and mass-tensor models. However, these techniques fail to preserve incompressibility. While the finite element method offers a more rigorous approach, its reliance on mesh discretization introduces challenges related to mesh distortion and ill-conditioning, particularly in scenarios involving large deformations and poor mesh quality.

To address these limitations, we introduce meshfree methods, which eliminate the need for explicit mesh generation and offer enhanced capabilities in handling complex geometries and substantial tissue deformations.

In this presentation, we will focus on the efficacy in simulating large deformation problems using reproducing kernel particle method (RKPM), highlighting its potential for accurate and patient-specific post-operative prediction in surgical applications.

作正顎手術時只涉及到骨骼移動,無法預測軟組織變形.

術後預測因人體的幾何複雜且軟組織形變量大而難以經濟(有效)且客製化(patient specific)地執行。

實務上(一般商用軟體)常使用的線性插值法、Mass-spring model或Mass-tensor model無法維持體積不變性(不可壓縮性),準確性有待改進；研究上常用的有限元素法則有網格品質不佳造成的網格扭曲與ill-condition等困難。

為此，我們引入Meshfree method，它不依賴於傳統的網格劃分，能夠更有效地處理複雜幾何形狀和大幅度的組織形變。

本報告中我們將引入reproducing kernel particles method (RKPM)，並展示其在模擬大形變問題的能力，與模擬術後預測方面的潛力。