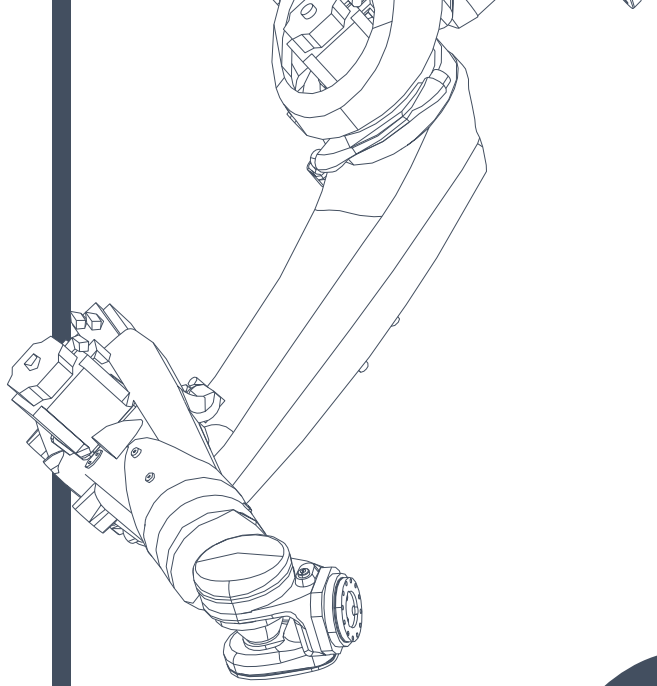
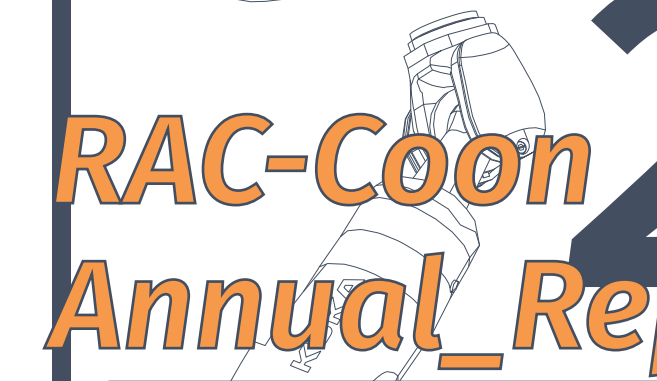
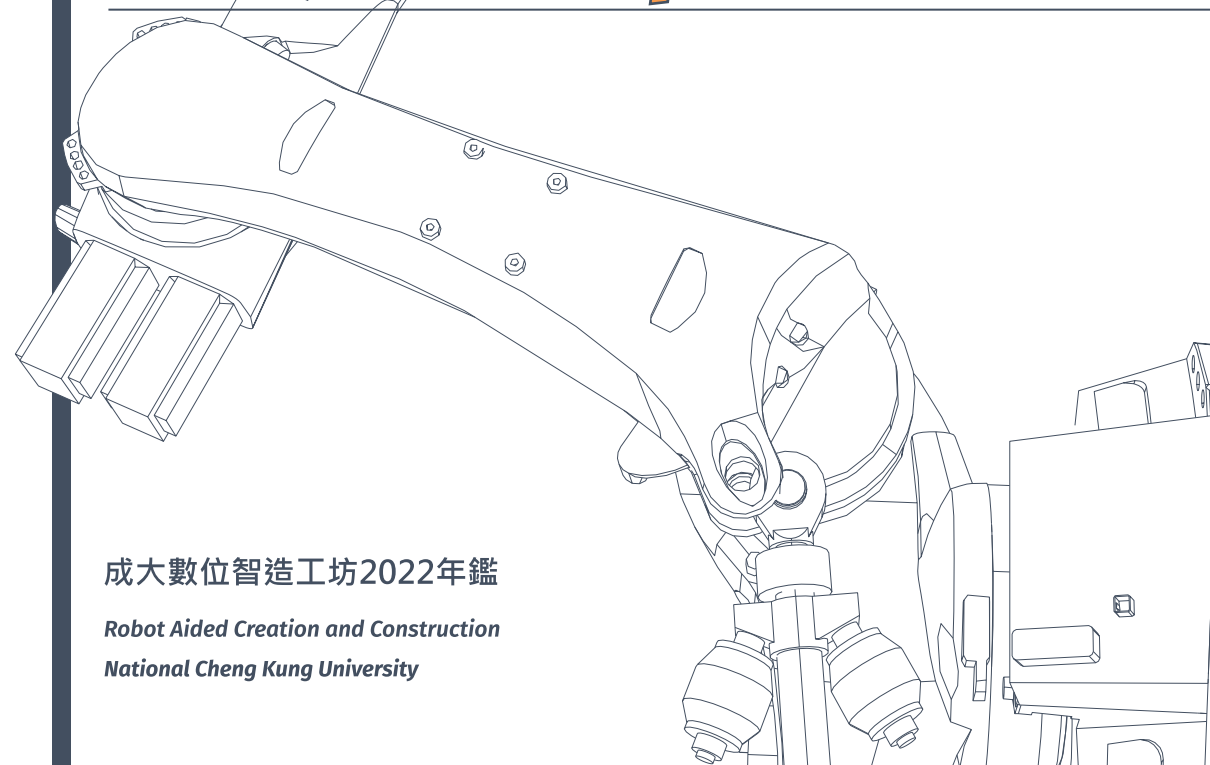
RAC-Coon Annual_Report 2022







成大數位智造工坊2022年鑑

Robot Aided Creation and Construction

National Cheng Kung University

RAC-Coon 2022 Annual_Report

RAC-Coon Annual_Report

Robot Aided Creation and Construction
National Cheng Kung University

2021

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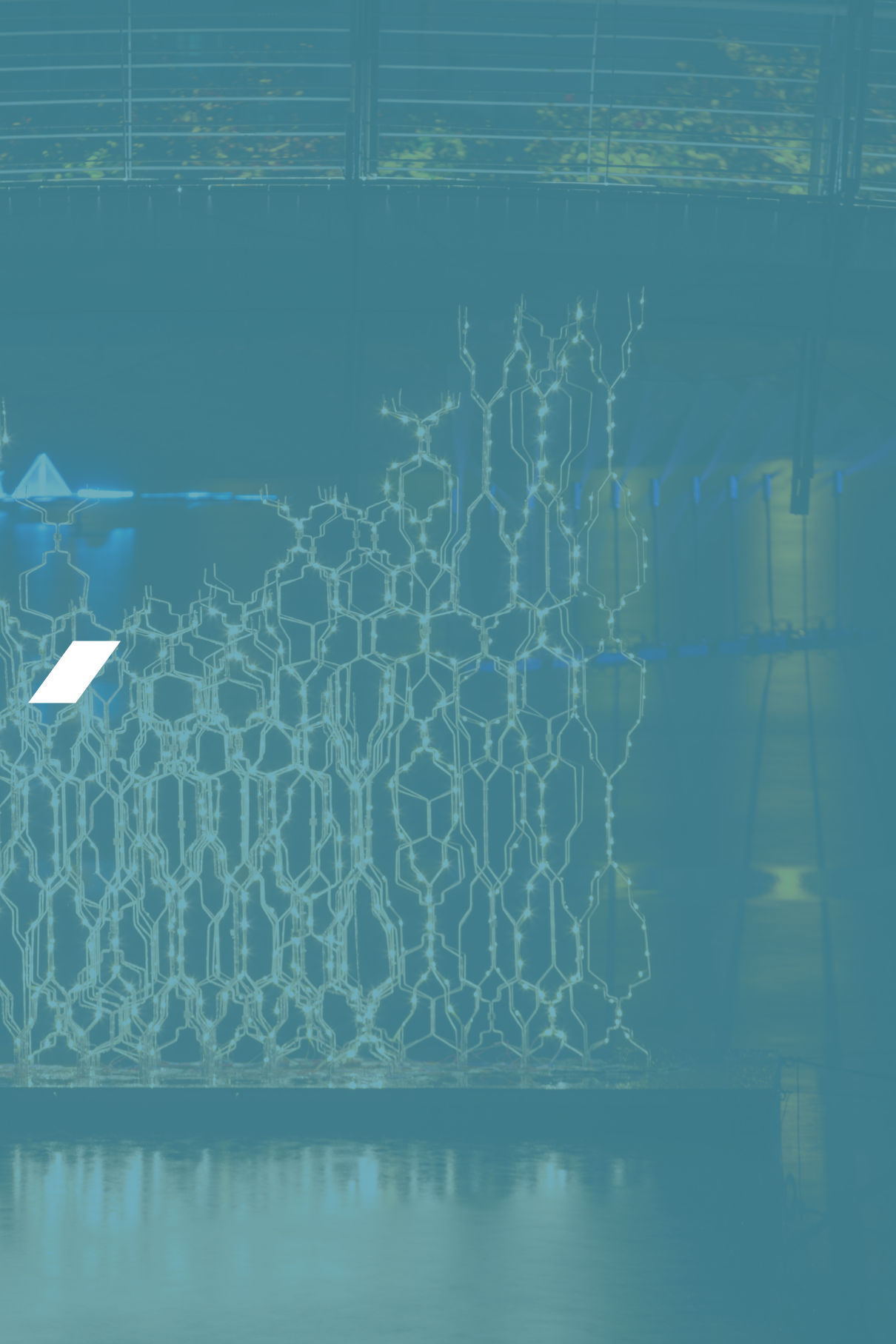

Project

Graffiti Wall

窗前明月光

設計者 / Designers

蕭瑋廷 | 鄭方哲 | 許家碩
Hsiao, Wei-Ting | Cheng, Fang-Che | Hsu, Jia-Shuo

指導老師 / Advisors

鄭泰昇 | 沈揚庭
Jeng, Tay-Sheng | Shen, Yang-Ting

協助製作 / Assistants

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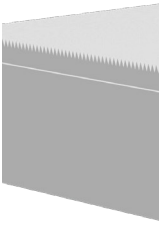
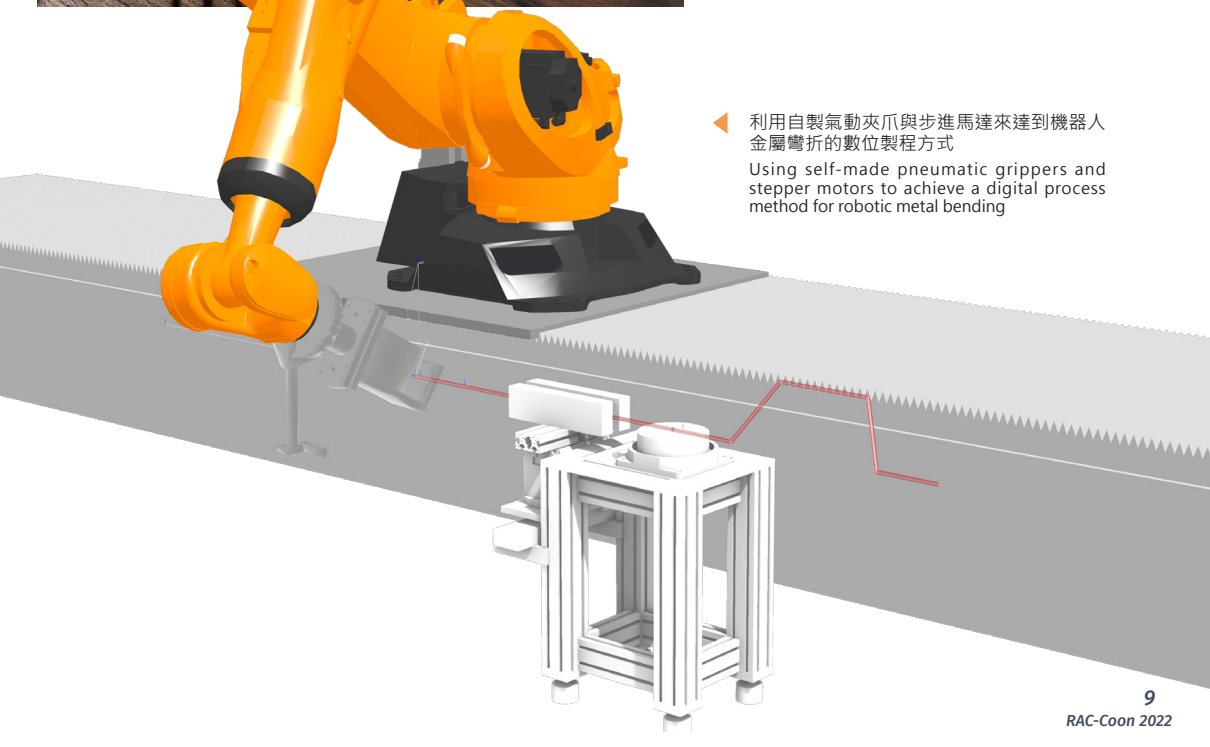
Wu, Yi-Chun | Liao, Zi-Ying | Hsieh, Tzu-Hsin
顏嘉慶 | 葉冠妤 | 黃廉凱
Yen, Chia-Chin | Yeh, Kuan-Yu | Huang, Lien-Kai



▲ 介紹影片
Introduction video

鐵花窗曾經是台灣早期隨處可見的景象，1950 年人們開始在窗戶前安裝具有圖騰的金屬花窗以防止小偷進入家中。但鐵花窗很快就不僅僅是一種防盜措施，它們變成了另一種日常生活中的藝術，並隨著時間鏡頭調整到現在，花窗早期的防盜功能漸漸移覺成一種「家」的意象。RACCOON 數位製造工坊以鐵花窗作為設計的出發點，將鐵花窗的圖騰元素作為此裝置的主體造型單元，透過離散設計的方式將單元排列出引人入勝的視覺效果，並以數位製造的方式翻新傳統鐵花窗的創意和語彙。

Window gratings were once a ubiquitous sight in Taiwan. Starting around the 1950s, homeowners began installing stylized metal barriers in front of their home windows to keep out thieves. But window gratings soon became more than a theft-deterrent. They turned into elaborate art that reflected the tastes and interests of those who commissioned them. Today the theft-deterrent function of the window gratings gradually shifts into a home concept. We use window gratings as a design concept, using the totem element of the window gratings as the main modeling unit of this installation. Arrange all the units to create a fascinating visual effect through discrete design. The production method of Pattern Light renovates the creation and vocabulary of traditional window gratings in a digital manufacturing method.



利用自製氣動夾爪與步進馬達來達到機器人金屬彎折的數位製程方式

Using self-made pneumatic grippers and stepper motors to achieve a digital process method for robotic metal bending

Lang Form

崚

設計者 / Designers

蕭瑋廷 | 吳怡諄

Hsiao, Wei-Ting | Wu, Yi-Chun

指導老師 / Advisors

鄭泰昇 | 沈揚庭

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龔柏閔 | 游婕

Kung, Po-Ming | Yu, Chieh

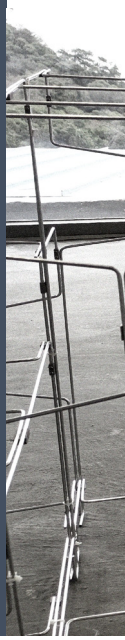
協助製作 / Assistants

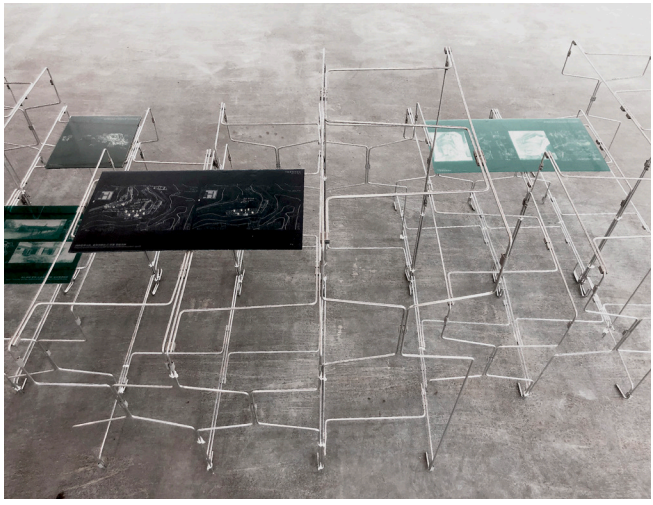
鄭方哲 | 許家碩

Cheng, Fang-Che | Hsu, Jia-Shuo

陳少華 | 葉冠妤

Chen, Shao-Hua | Yeh, Kuan-Yu





" 崚 " 是由成大數位智造工坊與成大設計中心合作，在馬祖「戰地轉身、轉譯再生」梅石展覽區展出 6 米的金屬工藝展示長桌，將馬祖山海交錯的山崚，透過低調內斂的金屬彎折轉譯而成。

為縮短製造時間和輕量化空運到馬祖組裝的需求，將 6 米長桌分割成 20 個 30 公分長的模矩化單元，應用 RACCoon 機械手臂的人工協作，金屬彎折工法精準且迅速彎折不同單元，再使用 3D 列印大量接頭，便能在現場快速組裝而成，最後與設計中心展示的作品結合。

Interlace Forest

織蔭

設計者 ／ Designers

郭建鎧 | 傅政文 | 黃柏熹
Kuo, Chien-Kai | Fu, Cheng-Wen | Wong, Pak-Hei
鄭崇明 | 李奕璇 | 李芷沅
Zheng, Chong-Ming | Lee, Yi-Xuan | Lee, Zhi-Yuan

指導老師 ／ Advisors

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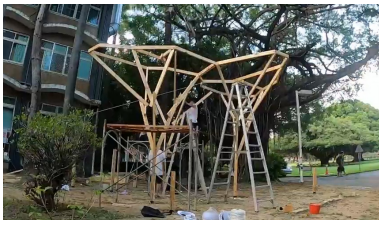
技術指導 ／ Technical Guidance

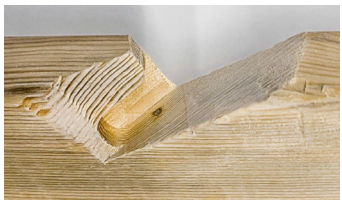
王宓琦 | 黃廉凱 | 高有旻
Wang, Mi-Chi | Huang, Lien-Kai | Gao, You-Min

▲ 介紹影片
Introduction video

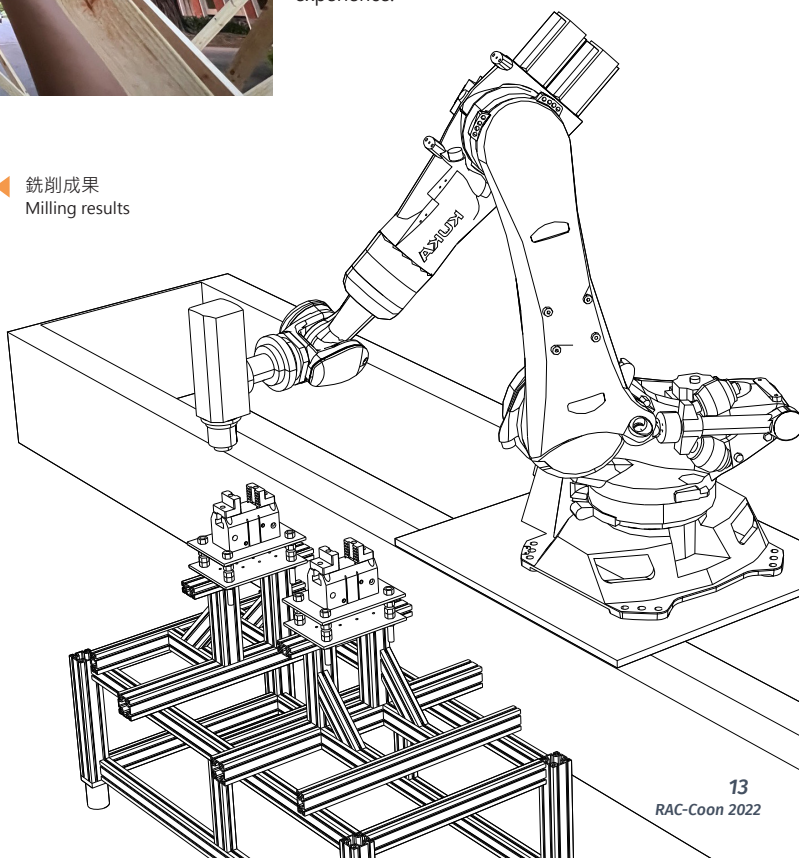


在這個設計中，我們使用參數化的樹結構來彎曲到周圍的樹中。 此外，使用清晰的幾何邊界來暗示校園視軸。
根據周圍環境的關係進行形態查找。 空間之間的關係創造了一條連接校園虛擬空間的路徑。作品形成的空間關係。 每一層的高度是根據人體的尺度和視野，以及步行路徑形成的空間感覺。設計過程中立柱位置的變化。考慮了每列支持的單位。定義露台和體驗路徑。

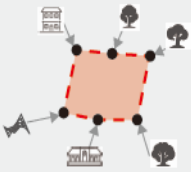
In this design, we use a parameterized tree structure to bend into the surrounding trees. In addition, a clear geometric boundary is used to imply the campus visual axis.
The form finding based on the relationship between the surrounding environment. The relationship between spaces creates a path to connect the virtual space of the campus.The spatial relationship formed by the work. The height of each level is based on the scale of the human body and the field of view, and also the spatial feeling formed by the walking path. The change of the column position in the design process.The units supported by each column was considered.Define the patio and the path of the experience.



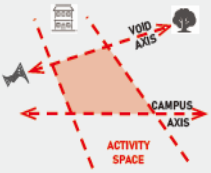
銑削成果
Milling results



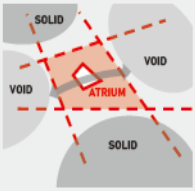
Form Fiding



POINTS CONTROL

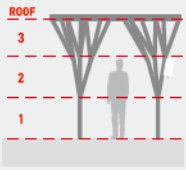


AXIS CONTROL

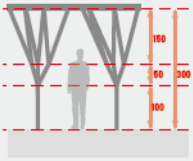


VOID-SPACE CONNECTED

Spatial Relationship



THREE LAYERS WITH ROOF

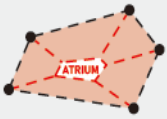


HEIGHT OF EACH LAYER

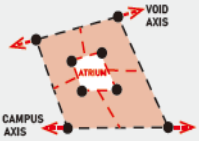
ATRIUM

Column Location

COLUMN DEFINE PATH

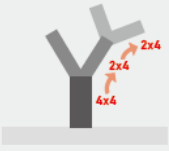


COLUMN DEFINE SPACE

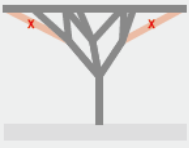


AXIS DEFINE COLUMN

Variables of Branches



4x4 & 2x4

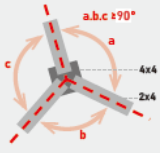


LENGTH CONTROL

ANGLE CONTROL

Bottom - Middle Joints

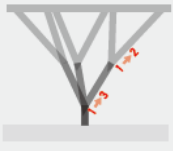
THREE BRANCHES



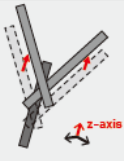
ANGLES BETWEEN 2x4

DOVETAIL JOINT

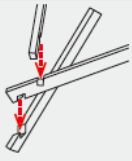
Middle -Top Joints



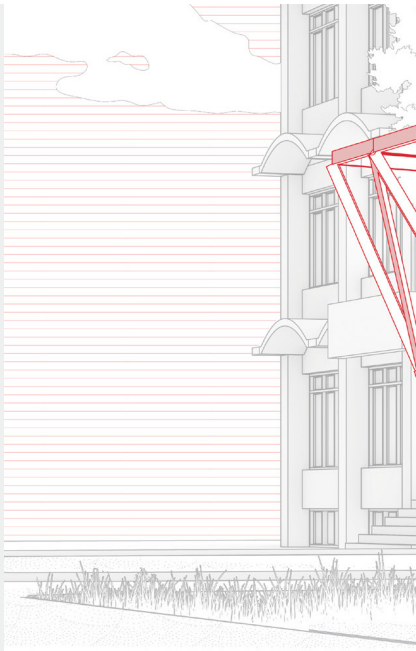
TWO BRANCHES



MOVE ALONG Z-AXIS

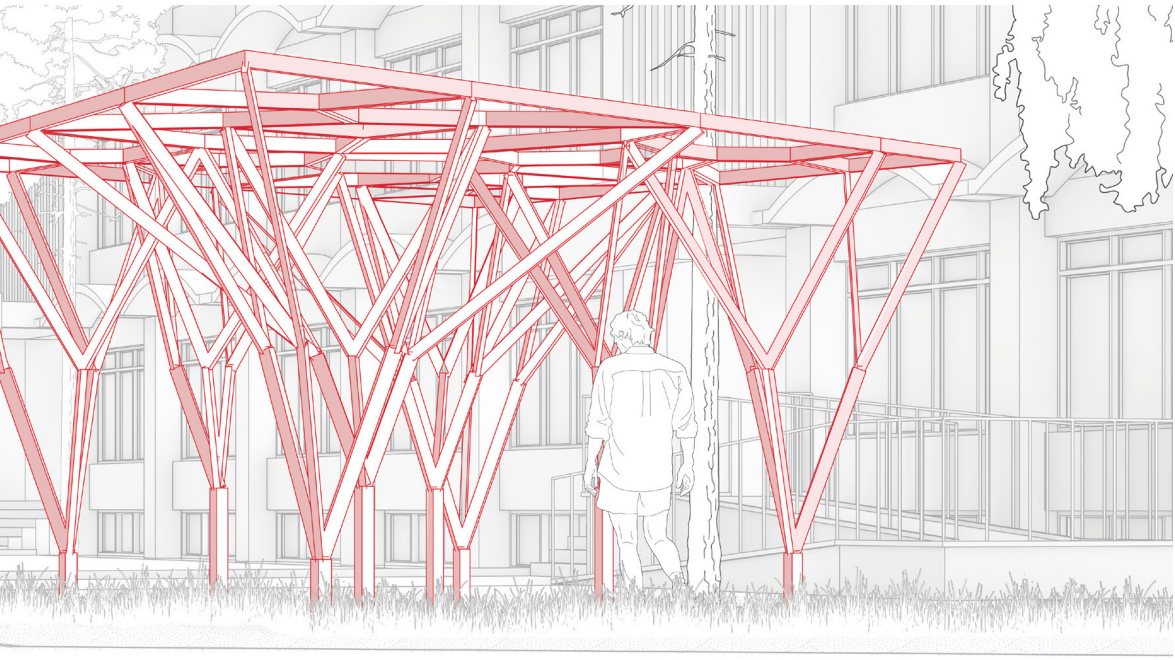


CROSS HAIVED JOINT

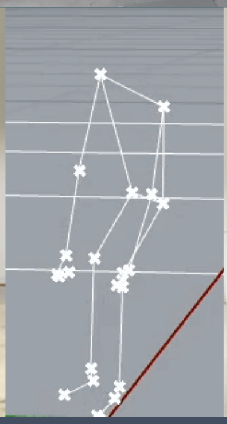


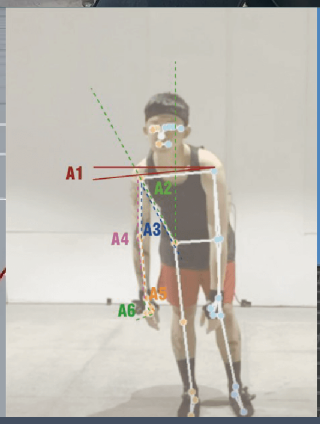
材料的大小由穩定性和組件粘合決定，組件的長度由機器人的加工限制和單元的穩定性決定。B-M 層分支從下到上為 1 到 3，M 層分支之間的夾角必須大於 90 度。 與機器人組裝時，燕尾榫上寬下窄。M-T 層會是 1 到 2 個分支，T 層搭接的位置控制會符合 M 層的 z 軸軸線，交接處採用交叉半搭接。

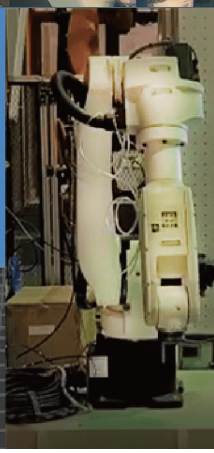
The size of the material is determined by stability and component bonding, the length of the components is determined by the processing limitations of the robots, and the stability of the unit. The B-M layers branches will be 1 to 3 from the bottom to the top, and the angle between the branches of the M layer must bigger than 90 degrees. To assemble with the robots, the dovetail tenon is wide upper and narrow lower. The M-T layers will be 1 to 2 branches, and the position control of the T-layer lap joint will conform to the z-axis axis of the M-layer, and the cross-half lap joint is used at the junction.



實構紀錄
Construction record







Dancing with Robot

人機共舞

設計者／Designers

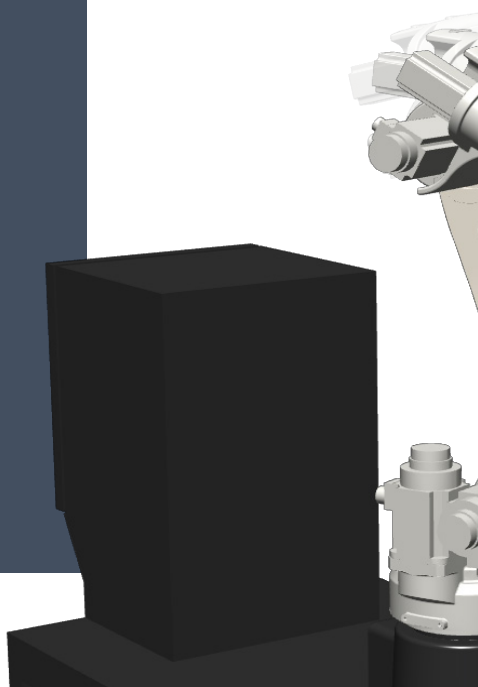
許家碩 | 王宓琦

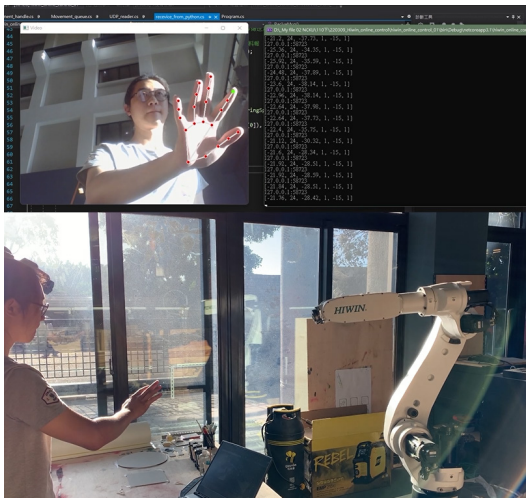
Hsu, Jia-Shuo | Wang, Mi-chi

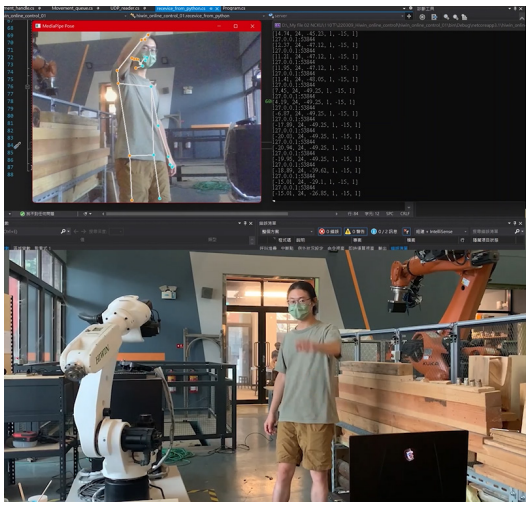
指導老師／Advisor

沈揚庭

Shen, Yang-Ting

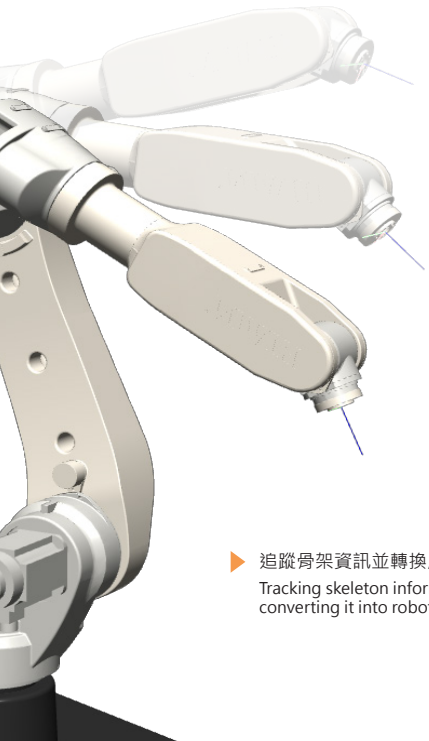




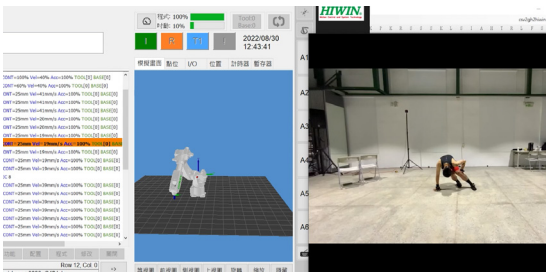


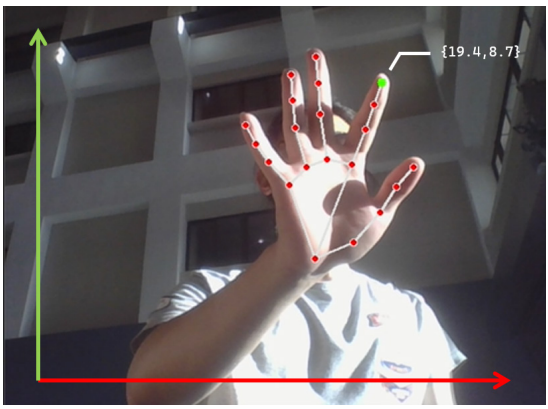
影片
Video

本研究為科技部計畫：島嶼演譯：科技藝術場域轉譯與跨域共舞創作計畫 - 以馬祖為實踐基地 (1/2) 之子計畫之一，目的在於將機器手臂技術應用於科技藝術與舞蹈轉譯上，期望可以利用場域轉譯以及跨域合作的創作發展人機共舞的表演呈現以及相關技術發展。本研究發展兩種型式的人機共舞流程，分別為教導型與鏡像型，人機共舞教導型流程主要是先記錄下舞者的動作再將其資訊轉換為機器手臂的動作，讓機械手臂的動作路徑以舞者「教導」的方式完成，由舞者教導動作後，透過姿態感知以及資料處理和轉譯後，讓機器手臂可以執行相似於舞蹈的動作，是一種非同步的控制方式；而人機共舞鏡像型流程則是運用機器視覺即時偵測舞者的動作，並將特定關節資訊轉換為機械手臂的關節動作，以達到如「鏡射」控制方法，讓機器手臂可以同步與舞者進行共舞。



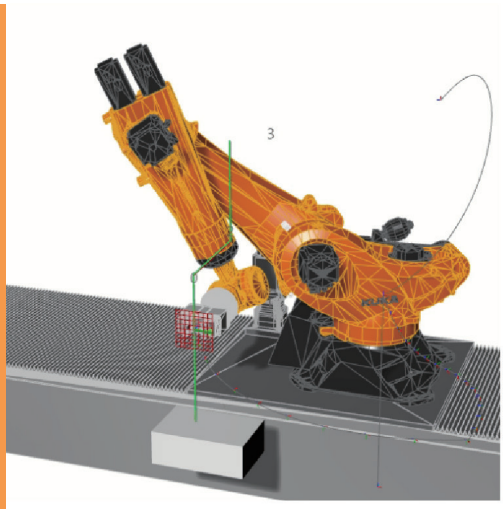
追蹤骨架資訊並轉換成機器人動作
Tracking skeleton information and converting it into robot motion in time

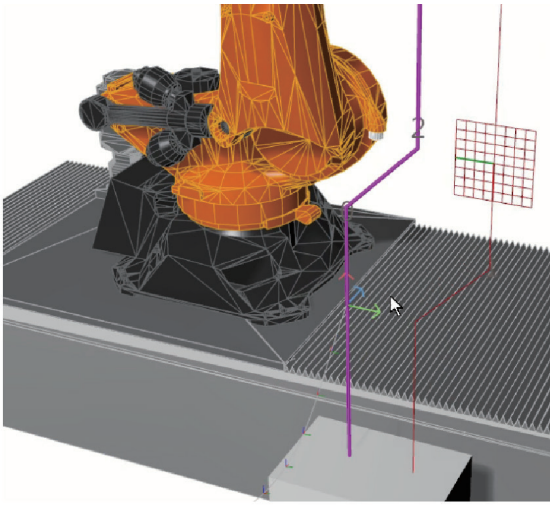


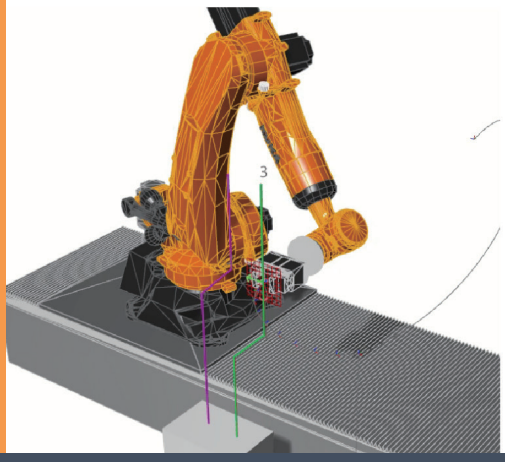


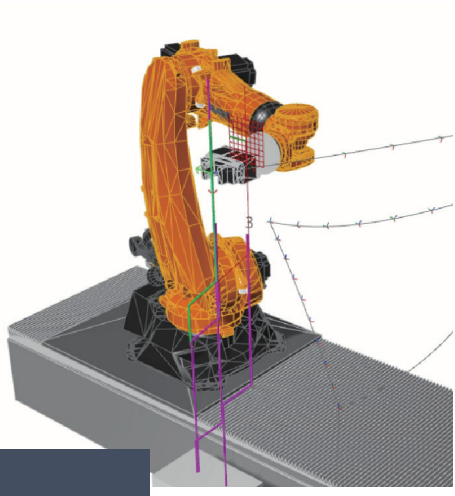

HIWIN®

Thesis









DFA Integration Workflow

機械手臂輔助金屬彎折工法應用於數位離散設計

設計者 / Designer

蕭瑋廷

Hsiao, Wei-Ting

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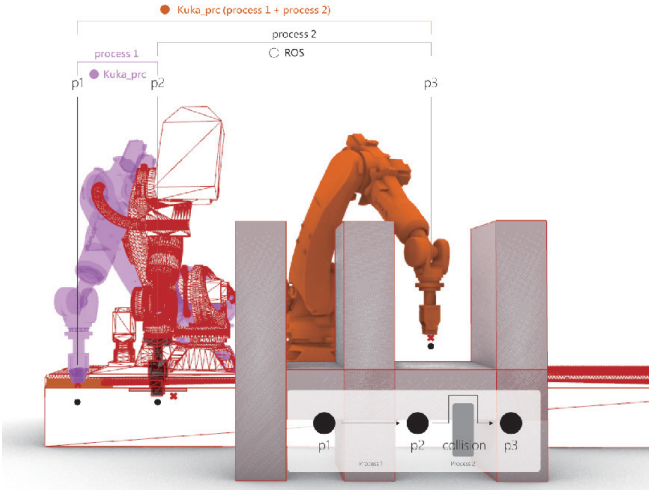
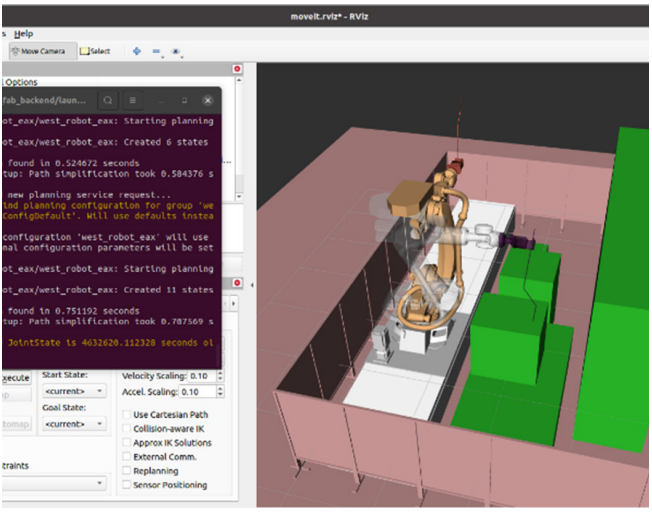
沈揚庭 | 顏嘉慶

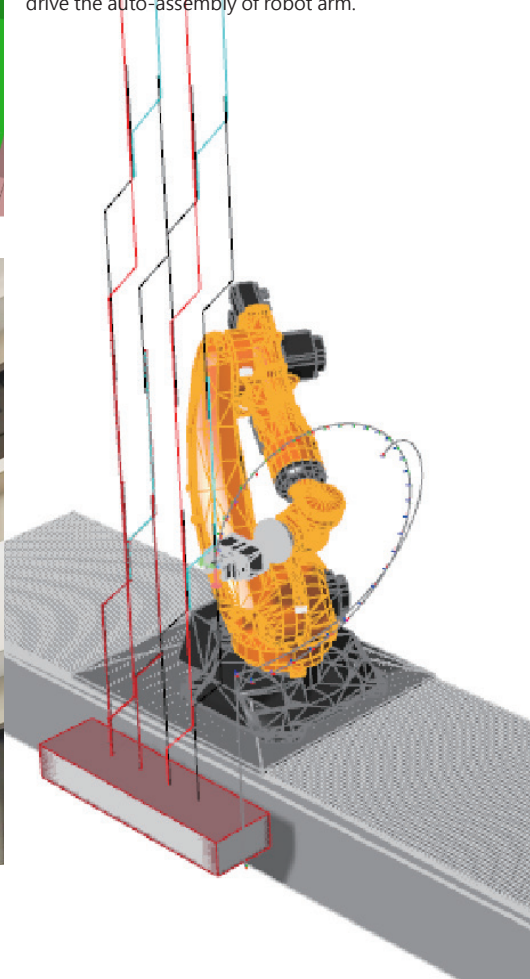
Shen, Yang-Ting | Yen, Chia-Chin





本研究藉由機械手臂偕彎折機發展金屬彎折與自動化組裝工法，從設計端運用離散設計 (Discrete Design) 生成可調適的零件，再以此聚積 (Aggregation) 成形式複雜的結構牆體，並在製造端透過參數式軟體分析每根零件的造型，生成相對應的製造參數衍生出機械手臂加工路徑，最後在製造端由機械人作業系統 (ROS System) 計算每根零件的組裝路徑，將設計、製造、組裝三者串連形成一體化的自動流程。

This research synchronizes a robotic arm and a bending machine to develop metal the rod bending and automated-assembly methods. There are three stages including design, fabrication, and assembly. In the design stage, the discrete design base on Grasshopper is used to generate adaptable components through aggregated components, they are composed to the complex wall structures. During the fabrication stage, Grasshopper with KUKA|PRC is used to analyze the relationship of components and generate the fabrication path of the robotic arm. Finally, in of the assembly stage, the ROS (Robot Operating System) compiles the assembly path to drive the auto-assembly of robot arm.



Hyperbolic Pavilion

雙曲亭

設計者 / Designers

張祖林 | 卓英儒 | 方昱揚
Chang, Zu-Lin | Zhuo, Ying-Ru | Fang, Yu-Yang
陳俊利 | 顏智弘 | 郭哲諺
Chen, Chun-Li | Yen, Chih-Hung | Kuo, Che-Yen
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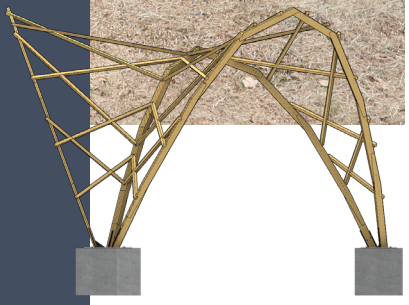
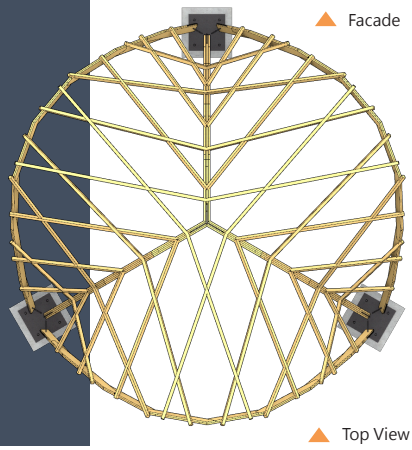
陳文禎 | 吳昱成 | 張芷菱
Chen, Wen-Zhen | Wu, Yu-Ting | Chang, Chih Ling



▲ Facade

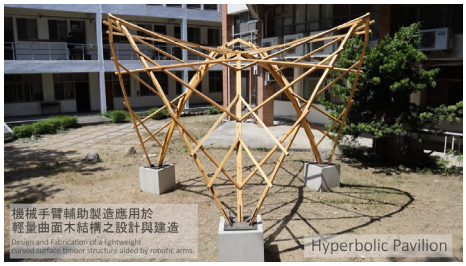


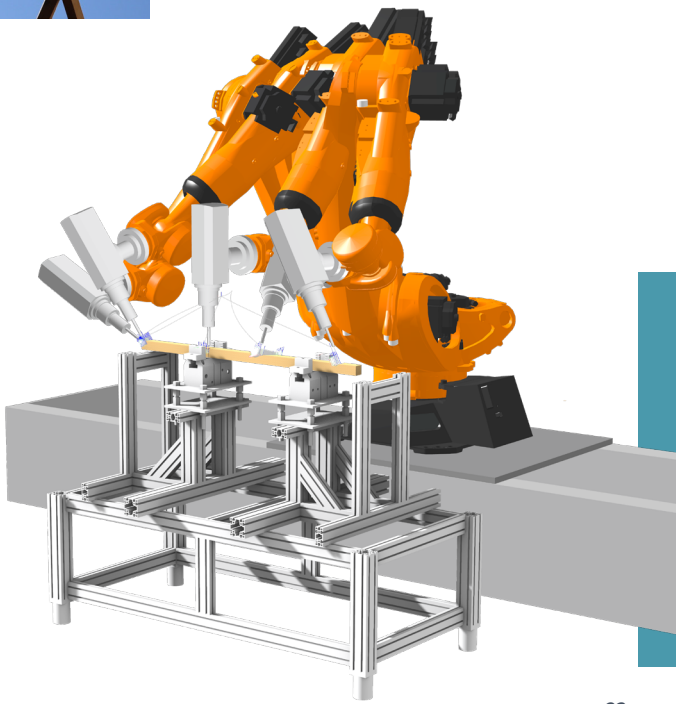
▲ Top View

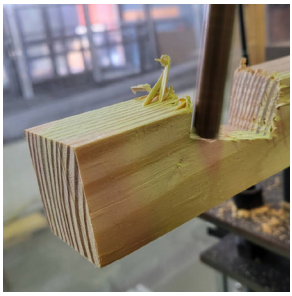
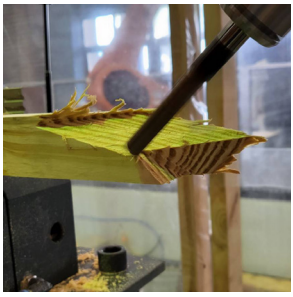
本設計之主題為以木材構築曲面造型，因木材為直線型材料，故選擇可藉由漸變斜率之直線構成的雙曲拋物面作為發展原型。首先由雙曲拋物面中點以 120 度圓心角擷取局部，再將其沿截邊鏡射構成一 120 度轉動對稱之造型，曲面之交界為主要支撐傳力路徑至地面之三道主拱，另有三道副拱定義造型之外周邊界。曲面本身以兩向交錯之木桁條構成，主拱與副拱以不等長之折線段拼接。機器手臂用於精準銑削木材各種角度不同之續接面。

The theme of design is to construct a curved surface with wood. Since wood is a linear material, a hyperbolic paraboloid, which can be formed by straight lines with gradient slopes, is chosen as the development prototype. First, a part is extracted from the midpoint of the hyperbolic paraboloid with a central angle of 120 degrees, and then mirrored along the truncated edge to form a 120-degree rotationally symmetrical shape. The junction of the curved surfaces is the three main arches that support the force path to the ground. Another three secondary arches define the outer perimeter of the shape. The curved surface itself is composed of two-way staggered wooden stringers, and the main arch and the secondary arch are spliced by folded line segments of unequal length. The robotic arm is used to precisely cut the continuous surfaces of various angles of wood.

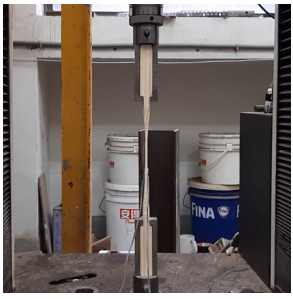
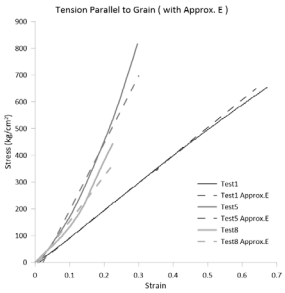
介紹影片
Introduction video

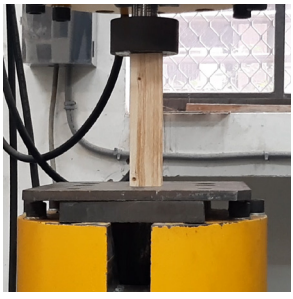
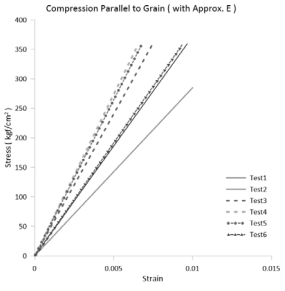




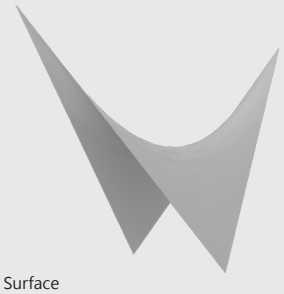




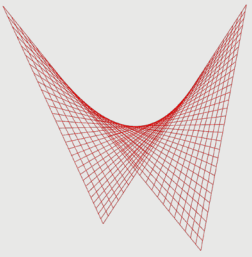

▲ 運用機械手臂六軸性能進行大量客製化加工
Use the six-axis capability of the robotic arm for "Mass Customization" machining

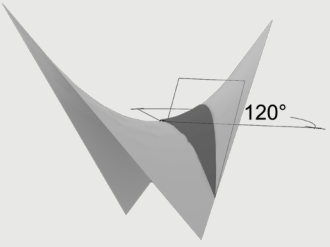



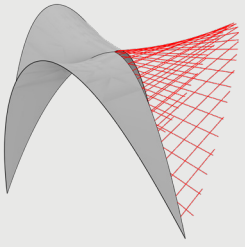
▲ 本案亦進行結構分析與材料試驗，善用結構組資源，進行跨領域整合
This pavilion also conducts structural analysis and material testing, making good use of the resources of the structural group for cross-disciplinary integration

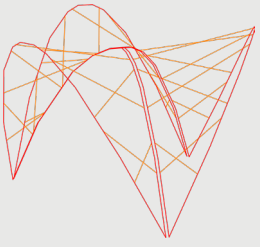

Original Surface


Linear Surface

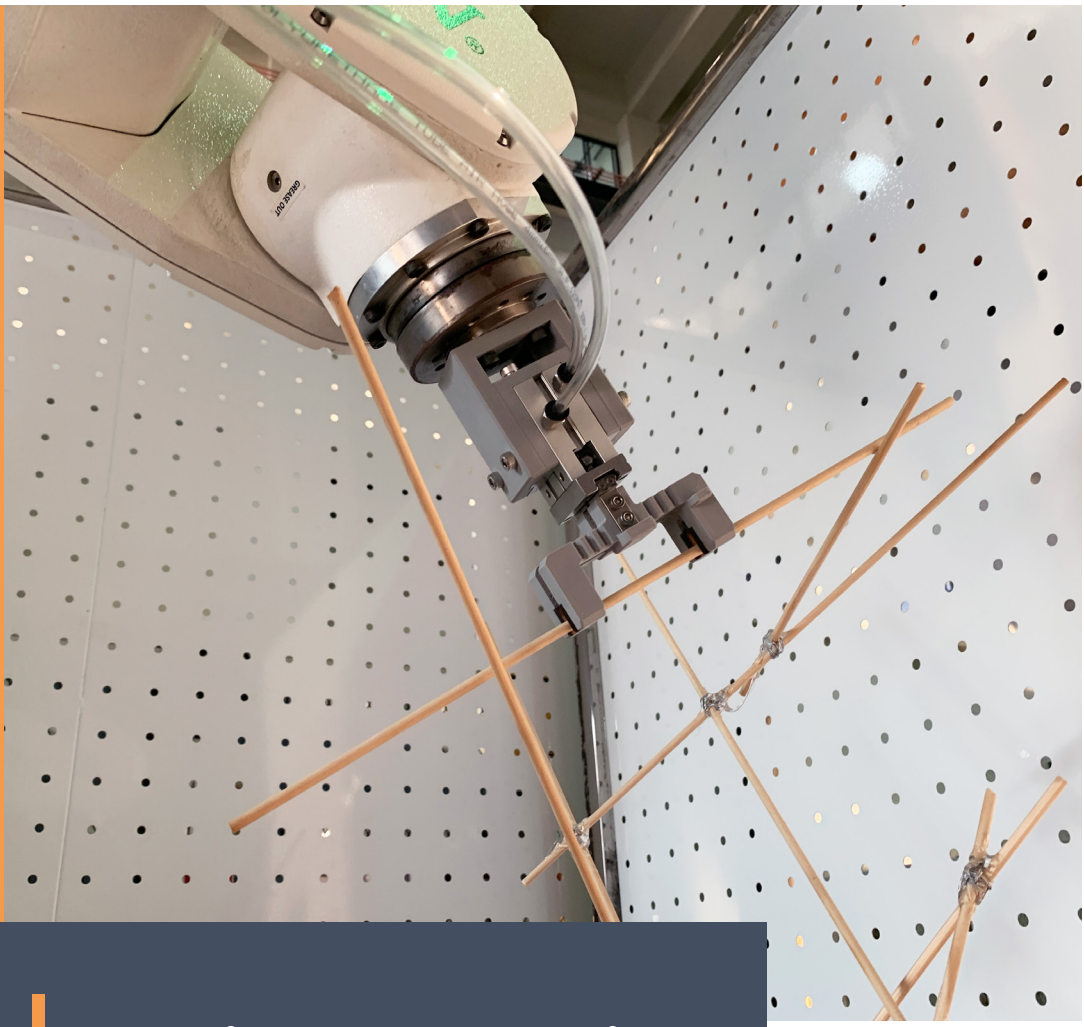


Split Surface


Divided Surface


Simplify Element

▲ 實構紀錄
Construction record



Robotic Collaboration Craft Based on Mixed Reality Interaction

混合實境機器人協作工藝

設計者／Designer

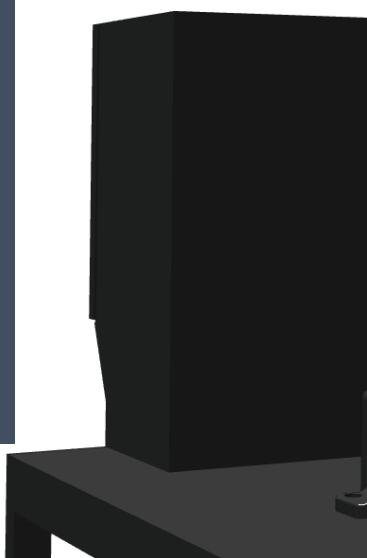
許家碩

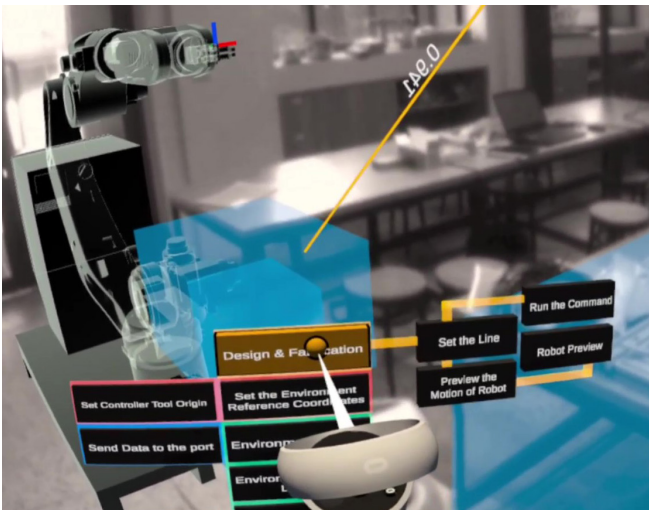
Hsu, Jia-Shuo

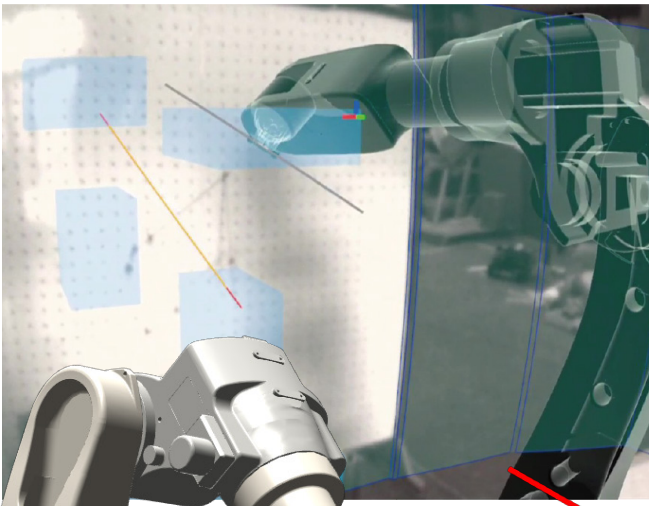
指導老師／Advisor

沈揚庭

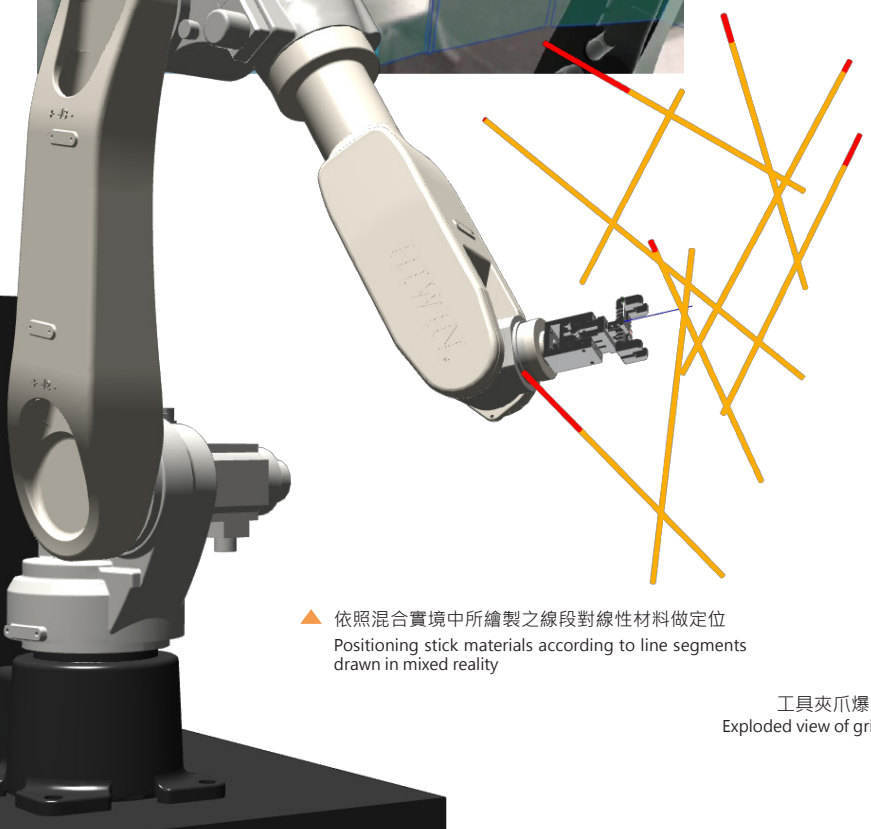
Shen, Yang-Ting



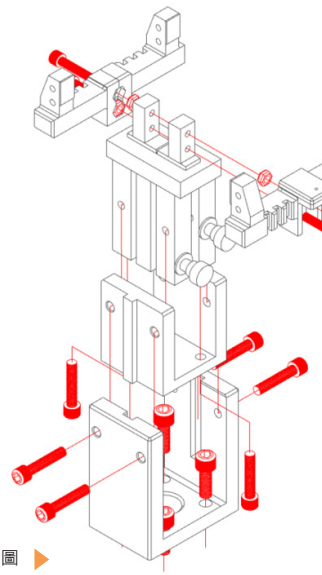




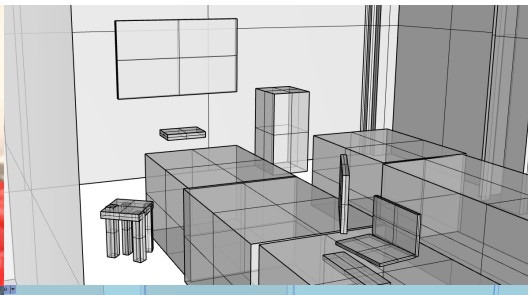
本研究中欲透過沉浸式科技與機械手臂製造之方式，試以探討人為判斷下所執行的非線性設計製造系統，並試圖導入環境資訊，使該系統的操作足以應對變化無常的現實環境。此研究以「虛實放樣」、「沉浸式設計操作」，以及「協作工藝」三個範疇來詮釋該系統，並透過 Oculus Quest 2 及上銀機器人，在程式語言與參數化軟體等環境的整合下完成了混合實境下機器人協作工藝的系統建置。在操作上以定位木棒材料作為該系統的製程方式，操作者可於混合實境中設計三維空間中之線段，再透過機械手臂抓取材料並精準定位於該設計線段上。

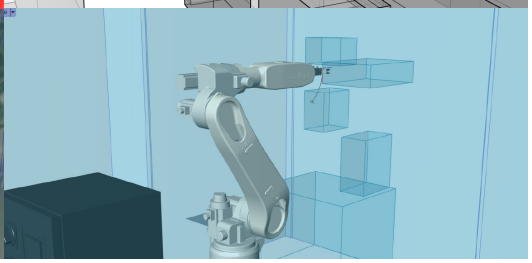


▲ 依照混合實境中所繪製之線段對線性材料做定位
Positioning stick materials according to line segments drawn in mixed reality



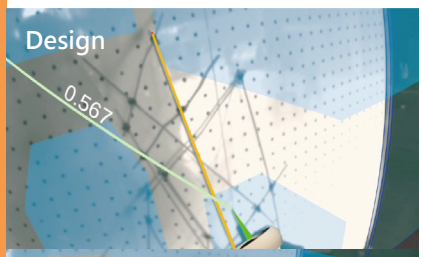
工具夾爪爆炸圖 ▶
Exploded view of gripper

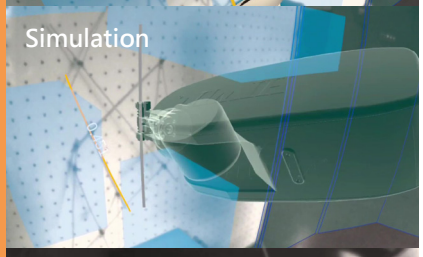



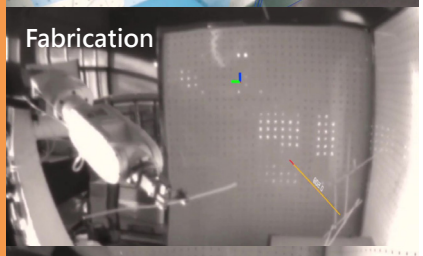


▲ 於混合實境中建置環境資訊，並及時與機械手臂系統整合
Build the environmental information in mixed reality, and integrate it with the robotic system immediately

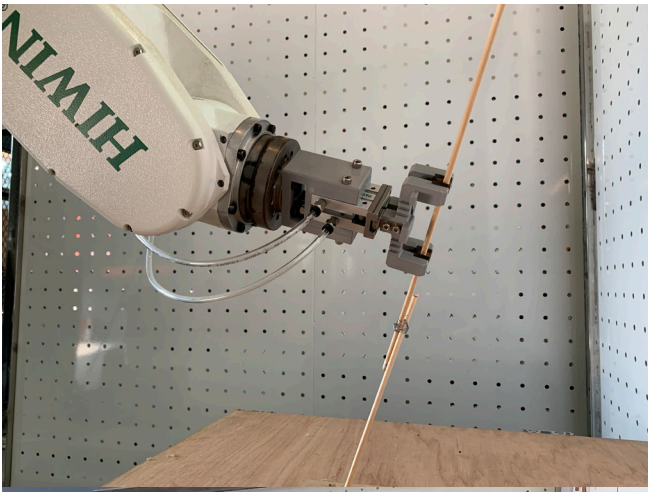
▼ 操作過程
Operation process

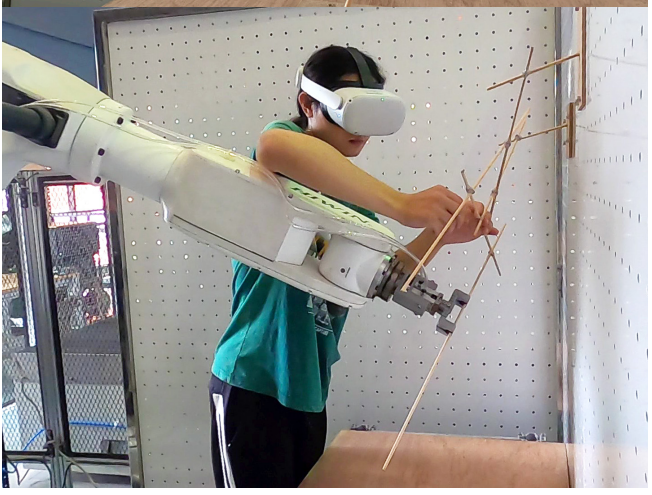


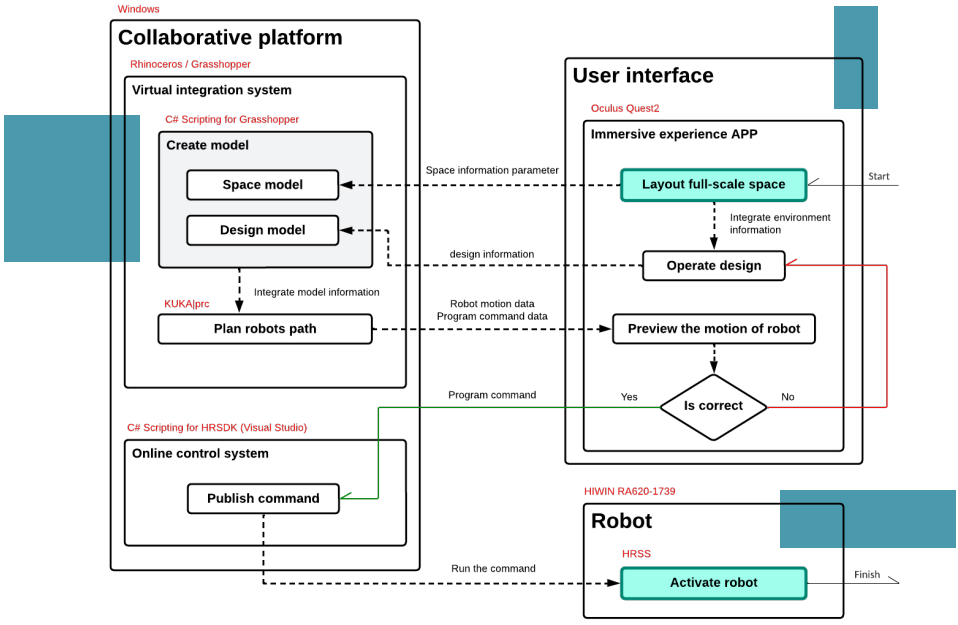




▼ 機械手臂完成定位後以人協助組裝
Human-assisted assembly after being positioned through the robot

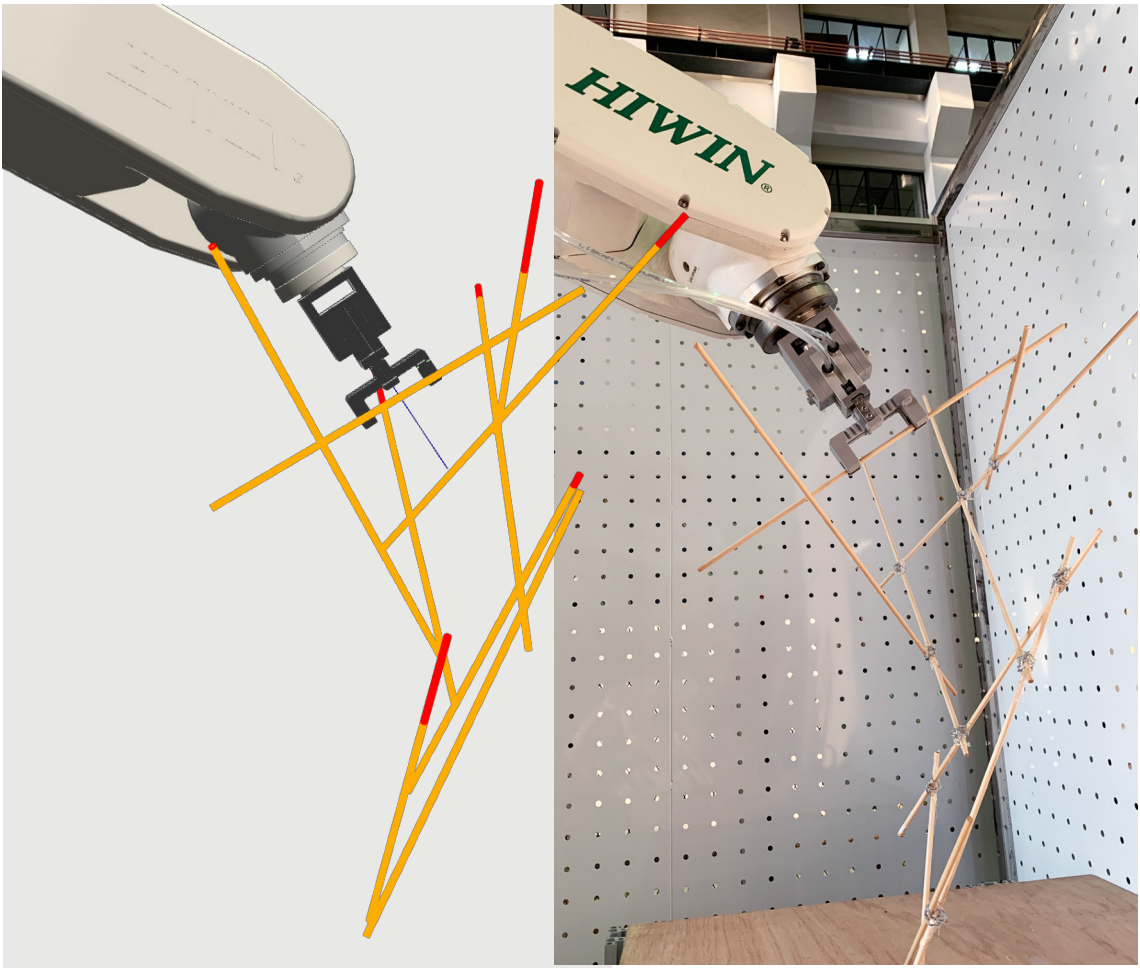






▲ 系統部署圖
System deployment diagram

▼ 實際操作過程紀錄
Actual operation process record



Papers

The Development of Robot-based Fabrication Apply to the Reproduction of Chinese Traditional Timber Structure

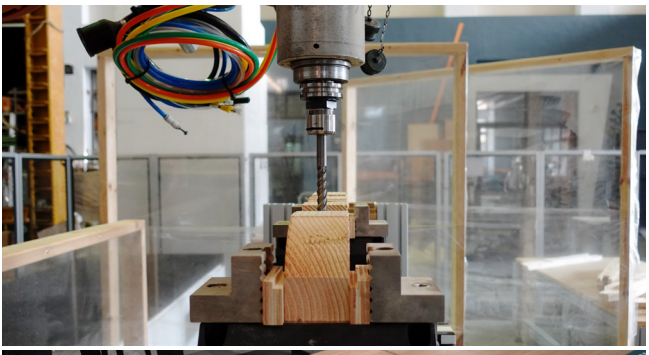
機器手臂製造與工藝數位化應用於傳統大木結構之再現

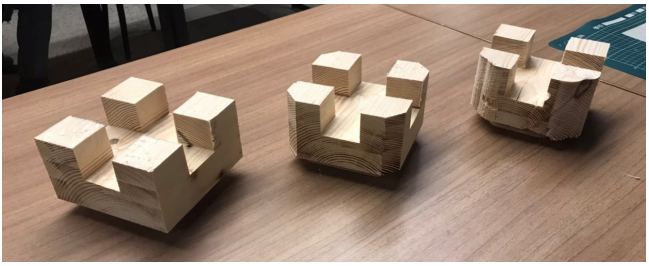
研究作者／Researchers

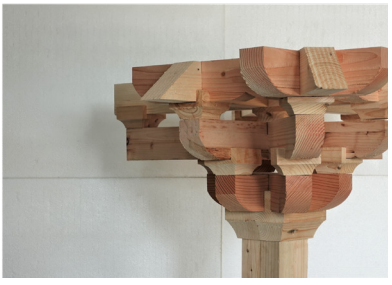
沈揚庭 | 王宓琦 | 黃廉凱
Shen, Yang-Ting | Wang, Mi-Chi | Huang, Lien-Kai
高有旻 | 顏嘉慶
Gao, You-Min | Yen, Chia-Chin

研討會／Conference

ACAIA (Association for Computer Aided Design in Architecture)
October 27-29, 2022 | University of Pennsylvania | Philadelphia, PA

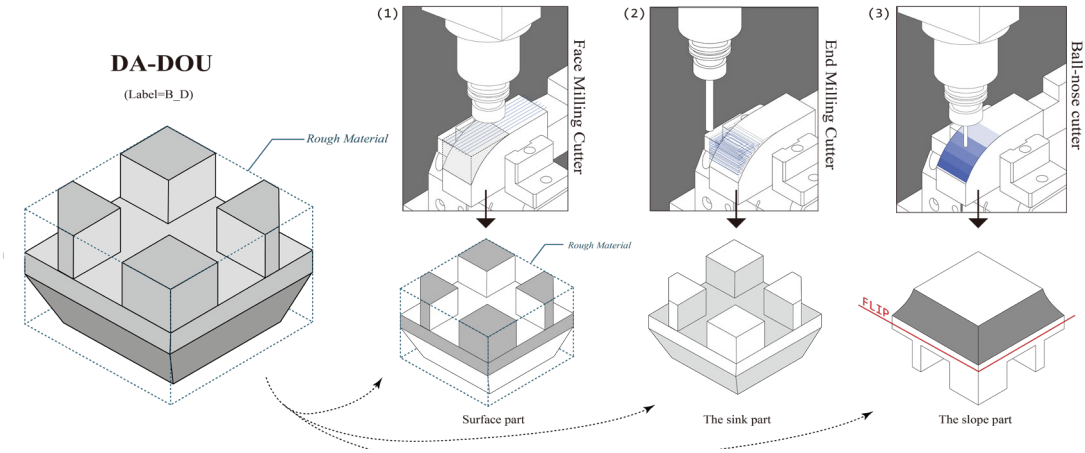


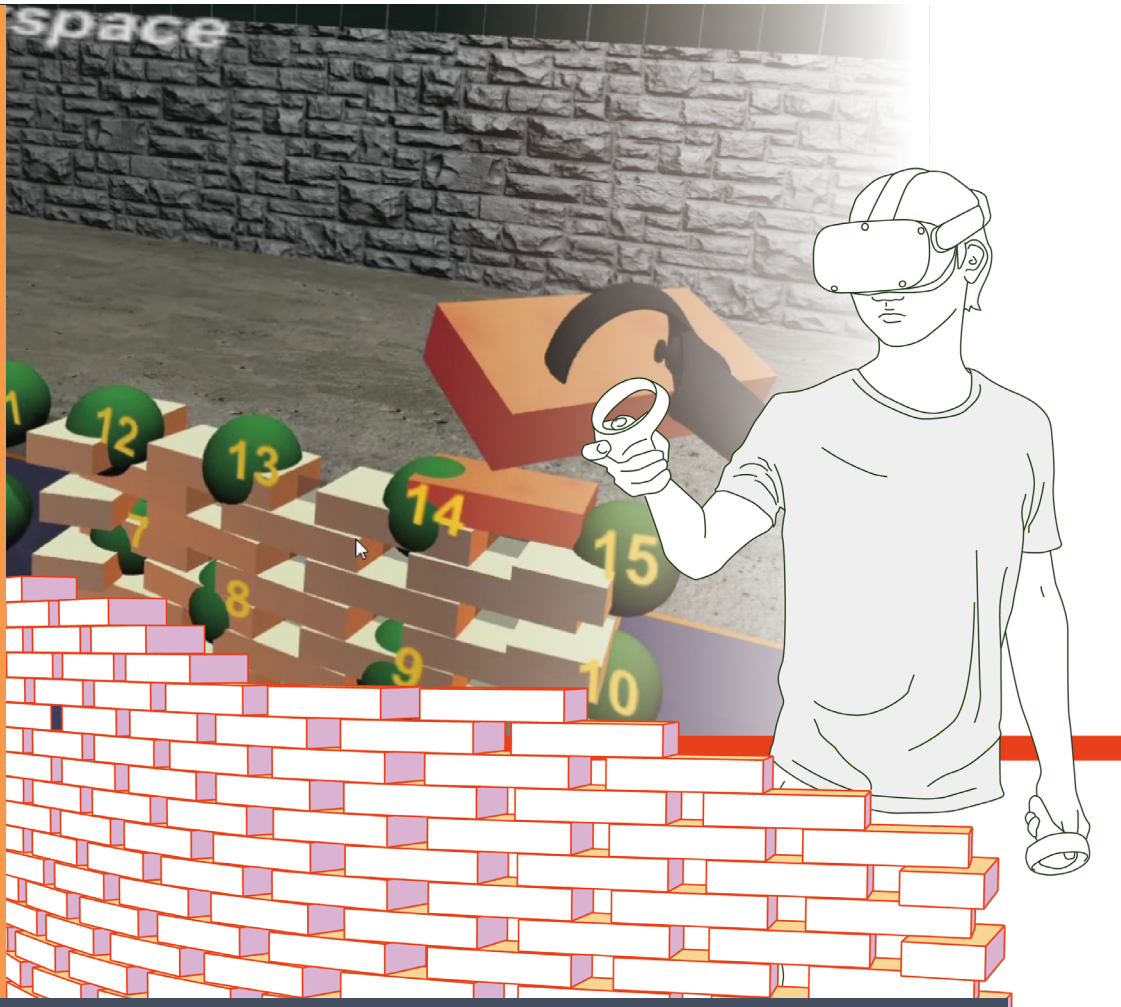




在本研究中，主要提出一種方法將古代漢式木構轉換成建築資訊模型並且利用機器手臂數位製造將構件再現。兩個方面進行古代木構的資訊保存以及實體再造，透過 BIM 技術將斗拱等古代木構造構件建立成資訊模型，我們可以建立幾何資訊與非幾何資訊成為資料庫。接著透過資料庫，我們將資訊導入 Autodesk Fusion 和 Grasshopper 進行機器人製造的加工資訊，KUKA 機器手臂則會根據加工資訊，設計工作路徑已經工具頭參數，此流程無須任何傳統工匠的手工，即可將木材精確的銑削成木構件。目前此製造流程已可生產出完整的斗拱原型，展現機器人製造在中國傳統木結構中的潛力。

This paper proposes a method to digitize the structure into BIM (building information modeling) and reproduce it via robot-based fabrication. By modeling these Dou-gong components with BIM technologies, we can establish a geometrical and non-geometrical 3D database. Then we use Autodesk Fusion and Grasshopper to design the robotic fabrication information whose information is transferred from 3D database models. Based on the fabrication information, including work paths and tool parameters, the KUKA robotic arm with six axes can precisely mill the wood materials into Dou-gong components without any traditional craftsman' s processing. The fabrication process we develop has produced the complete Dou-gong prototype which demonstrates the potential of robot-based craft fabrication in Chinese traditional timber Structures.





The Development of the Intuitive Teaching-based Design Method for Robot-assisted Fabrication Applied to Brick-laying Design and Construction

應用直覺教導式設計方法於機器人疊磚製造之研究

研究作者 / Researchers

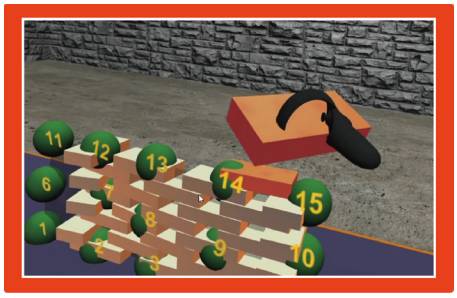
許家碩 | 沈揚庭 | 鄭方哲

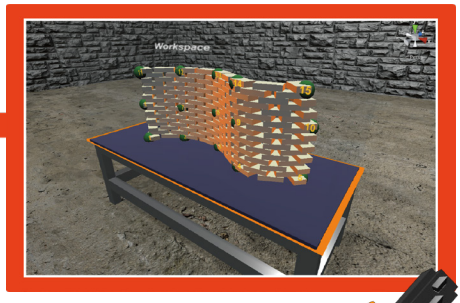
Hsu, Jia-Shuo | Shen, Yang-Ting | Cheng, Fang-Che

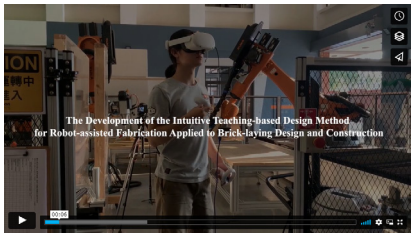
研討會 / Conference

HCII (Human-Computer Interaction Interational) - Posters

26 June - 1 July 2022 | Virtual Conference







介紹影片
Introduction video

本研究提出了實現直觀的機器人輔助疊磚系統，TRAC（Teaching-based Robotic Arm Construction）。這項研究以整合設計到建造的過程為目標，並輔助設計師實現機器人的輔助製造。研究中介紹了兩個階段的實踐步驟：1. 在 VR 中以直覺式設計方法執行砌磚動作模擬；2. 設計結果及時轉譯成機械臂砌磚工作路徑。而研究最後在通過工坊中 KUKA KR300 進行了系統的驗證，其結果印證了基於直觀操作的設計方式到機器人輔助建構的一體化工作流程。

This paper proposes the TRAC (Teaching-based Robotic Arm Construction) system, which aims to the intuitive robot-assisted bricklaying process. The goal of this research is to integrate the design-to-build process and help de-signers to implement robotic-assisted fabrication. The paper introduces two-staged steps of practice: 1. The teaching-based design method simulates brick-laying motion in VR to lead the intuitive design process; 2. The auto-translation from the design result to the robotic arm bricklaying working path. Finally, the verification of the system is implemented in the campus workshop via the KUKA robot. The final brick wall result shows the seamless working process from intu-itive teaching-based design to robot-assisted build.

沉浸式操作環境畫面
Immersive operating perspective

透過 TRAC 系統於虛擬實境中完成磚牆的設計並即時啟動機器人進行製造

Complete the design of a brick wall in virtual reality and run the robotic fabrication immediately through the TRAC system


Workshop Goals
Calibrate the depth camera mounted
scan and rebuild the physical enviro
mill the lumber.
RACCOON

Workshop & Event

2021/11/27 - 11/28

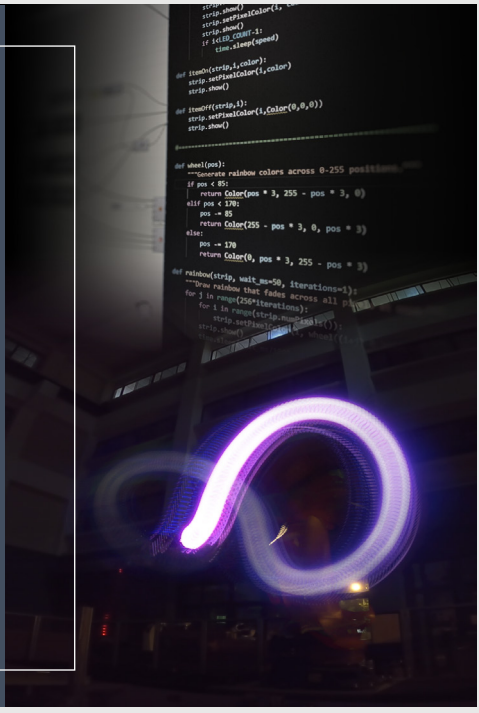
Computational Design Fundamentals Workshop

基礎電腦計算設計工作營

主講者／Speaker
顏嘉慶　Yen, Chia-Chin

協助／Assistance
許家碩　Hsu, Jia-Shuo
蕭瑋廷　Hsiao, Wei-Ting

參與人數／Participants
11



2022/01/16

Augmented Reality and the Applications in Fabrication

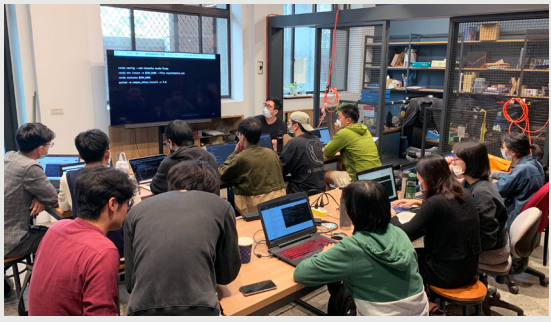
擴增實境與參數化設計整合工作營

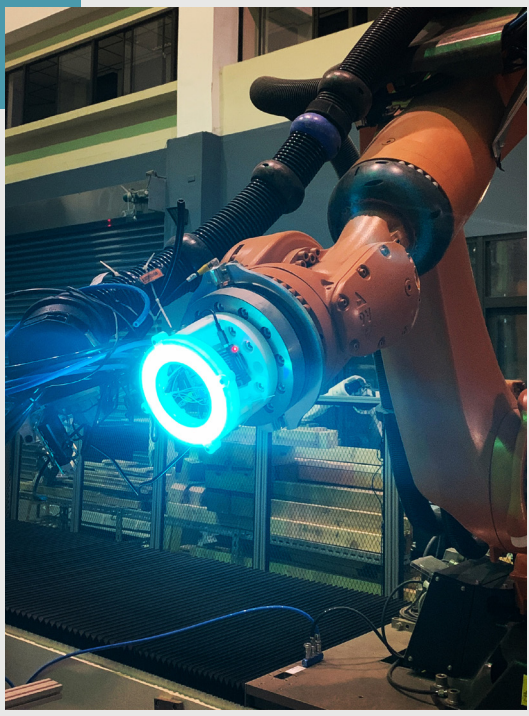
主講者／Speaker
許家碩　Hsu, Jia-Shuo
王宓琦　Wang, Mi-chi

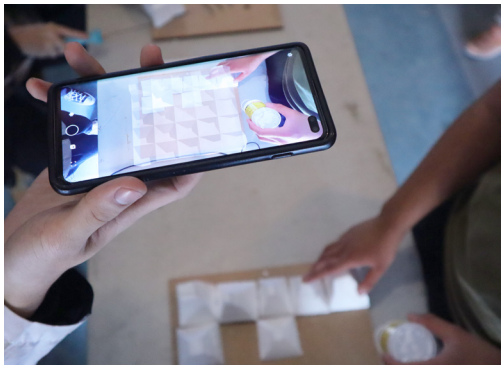
協助／Assistance
葉冠妤　Yeh, Kuan-Yu

參與人數／Participants
15

工作坊中介紹了幾項於建築數位領域中常見的電腦計算工具，其中課程包含了程式語言與機器人技術的介紹，同時也帶大家初步了解 Python/COMPAS 以及 ROS 機器人操作系統。在工作營的最後以機械手臂繪製光雕的專案來帶大家完成電腦計算工具到實體機器人運作的方式。







透過 Grasshopper 與其外掛軟體 Fologram，帶大家認識虛實整合技術應於參數化設計及數位製造之方法，並以實體的保麗龍切割案例讓大家體驗虛實整合技術下所輔助的製造方式。

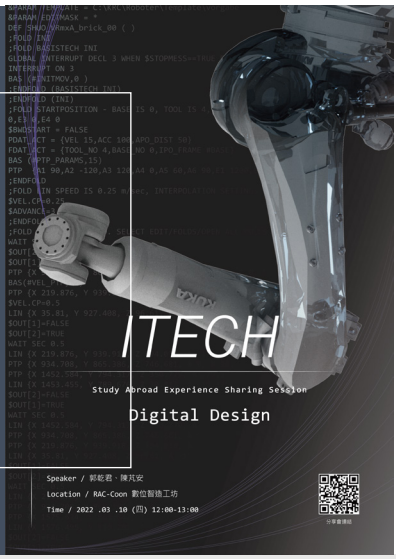
2022/03/10

ITECH Study Abroad Experience Sharing Session

ITECH 留學經驗分享會

主講者 / Speaker

郭乾君　Kuo, Chien-Chun
陳芃安　Chen , Peng-An



2022/08/10 - 08/12

Robotic Fabrication : Rod Bending

機械手臂輔助金屬彎折工作營

主講者 / Speaker

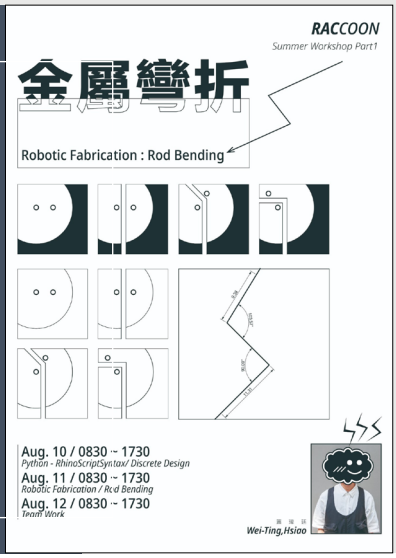
蕭瑋廷　Hsiao, Wei-Ting

協助 / Assistance

許家碩　Hsu, Jia-Shuo

參與人數 / Participants

10



2022/08/29 - 09/02

Robots & Computer Vision

機器人與電腦視覺工作坊

主講者 / Speaker

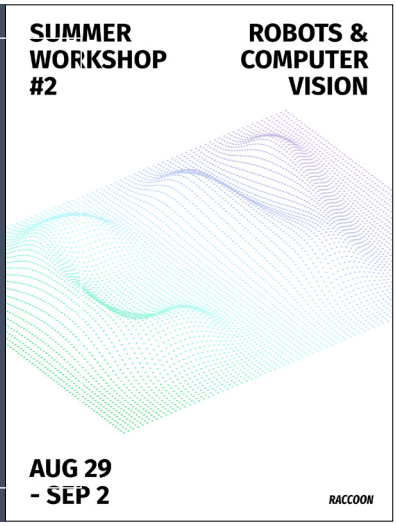
顏嘉慶　Yen, Chia-Chin

協助 / Assistance

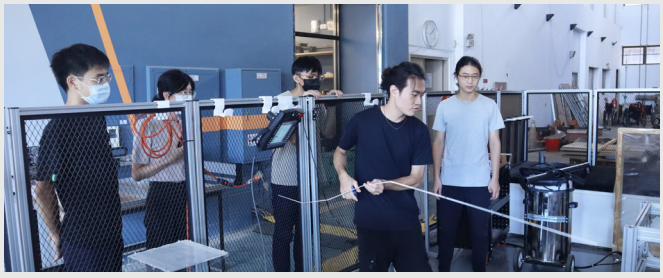
許家碩　Hsu, Jia-Shuo
黃楚樺　Huang, Chu-Hua

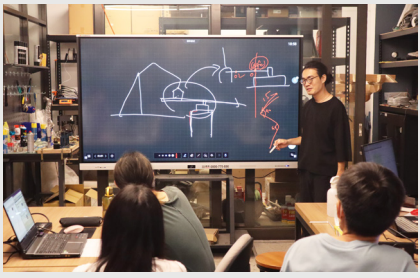
參與人數 / Participants

15

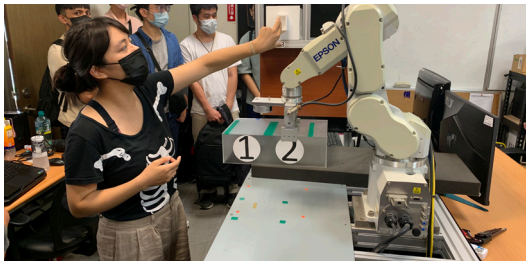


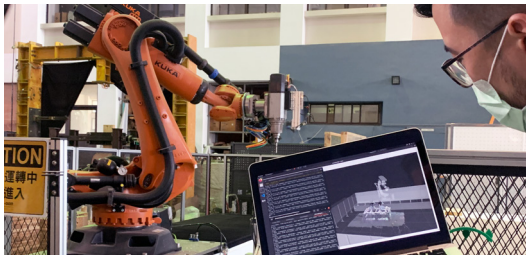
邀請現於德國斯圖加特大學就讀的郭乾君與陳芃安來分享於 ITECH 中所進行的專案，並帶大家認識從數位設計到機器人製造的思維。



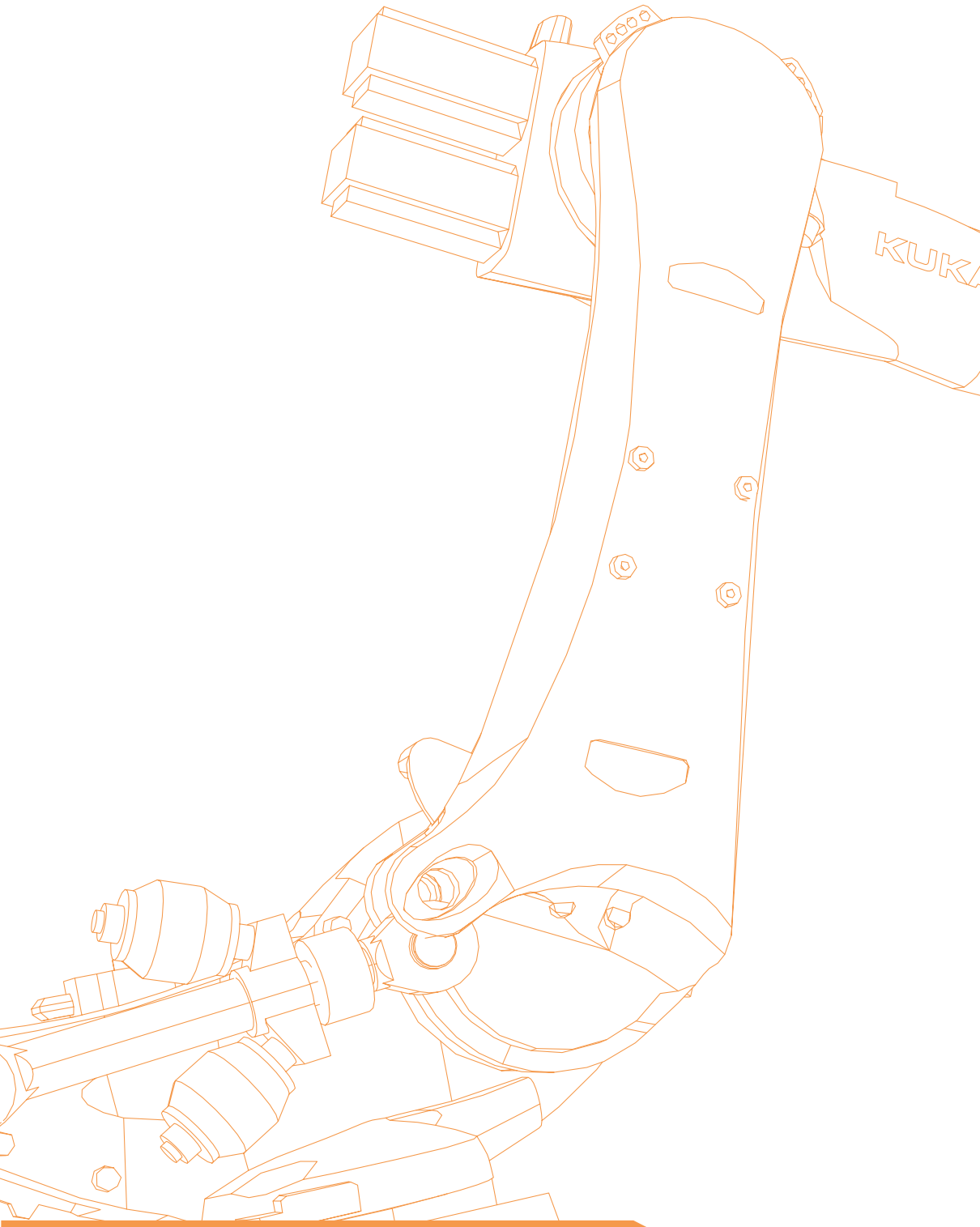


工作坊中帶領大家認識機械手臂製造結合金屬彎折工法的製程方式，其中以離散式設計作為設計的發展方法，再藉由機械手臂來完成金屬彎折製程的工作項目。





透過機器人與深度相機的整合，帶領同學了解電腦視覺應用於數位製造的可能性。其中以 ROS 進行深度掃描去試圖理解機器人的工作環境，並透過 CAD/CAM 軟體的整合使設計到製造的過程得以附加現場環境的資訊。工作營期間也到資工系連震杰老師研究室進行參訪，在實體的機器人展示中看到了機器人結合電腦視覺的發展性及潛力。



To be Continued ...

RAC-Coon 2022 Annual Report

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RAC-Coon

2022

Annual_Report

RAC-Coon 2022 Annual_Report