Increasing Productivity and Accelerating Decision Making by Bridging between Digital and Analog Workflows

Accelerating Company's Digital Transformation

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要旨

企業におけるデジタル・トランスフォーメーションは中々進んでいない状況だが，１つの要因としては既存のワークフローを変更しないといけないところにある。特にアナログワークフローを主としている分野では，デジタルワークフローに変更することへの障壁は高いと思われる。デザインシンキングプロセス，幾つかのカスタマーインタビューを行い，この障壁を取り除くには，既存のアナログワークフローとデジタルワークフローをシームレスに繋ぐことである。

また，昨今のコロナ禍の影響で北米では2020年３月からリモート・ラーニング／ワークの機会が増えており，この傾向はポストコロナ禍でも続くと思われる。そのため，特に教育現場ではどのように円滑な授業を行えるかの試行錯誤が続いている状態である。既存のオンライン会議では，資料の共有などはできるが，製品デザインの授業などは物理的な物体を使用したアイデア出しや議論ができない状態にあり，状況は深刻である。

KMLUS Solution Technology Divisionは，私達が所有しているコア技術である（AR技術, 画像解析技術, 構造化データ解析技術，非構造化データ解析技術）を使用し，市場に販売されているカメラ，プロジェクタ，3Dセンサーを組合わせることで，Projection with Interactive Captureという製品で課題を克服しようと取り組んでいる。それにより企業のデジタル・トランスフォーメーションを加速し，意思決定を加速し，仕事や授業の生産性を向上させることを目指している。

Abstract

Many companies are struggling in their transformation from analog to digital (DX). One reason is that transformation requires workers to change their preferred workflows. For those who perform analog specific workflows, it may be a high hurdle for them to transform into digital. Through the design thinking process and customer interviews, the Solution Technology Division (SLD) of KMLUS has identified a solution to reduce this hurdle by seamlessly bridging analog and digital workflows.

Due to the Covid-19 pandemic, many students and professional workers have been participating remotely in class/ work from their homes since early 2020. We assume that this trend will continue after the Covid-19 pandemic is eliminated. Many educational institutions and workplaces are trying to find ways to create a more face-to-face and hands-on environment where collaborators (teachers, students, workers) can interact and learn like they did face to face before Covid-19. Current web conferencing systems can share document material with remote collaborators, but they are not able to effectively support ideation or discussion with physical objects. Therefore, the current remote environment poses a serious barrier to collaboration.

SLD owns important KM core IP including Augmented Reality (AR), Image analysis, and structured/unstructured data analysis technologies. We combine off-the-shelf hardware components, such as 2D cameras, depth sensors, and projectors to connect with our core software technology to create a platform system we call Projection with Interactive Capture (PIC). This system can seamlessly support the connection between analog and digital workflows and decrease the struggle of DX, enabling increased productivity and improved decision making at school/ workplace.

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1 Introduction

Many institutions/companies have tried to achieve Digital Transformation, but there are many hurdles. One of the challenges for DX is the resistance of users to change their current analog workflows. PIC aims to bridging between user's current analog workflows and new digital workflows. For example, web conferencing systems might have digital whiteboard functionality to draw something among participants, but with current technologies, users may struggle to draw something with a computer mouse or stylus, as the user experience is poor compared to traditional analog writing devices (e.g., lagging/latency issues). Many people still prefer to draw something on a physical paper/whiteboard with a physical pen/marker like they would in a classroom at school.

2 Technology

The primary goal of PIC is to enable the seamless bridge between analog and digital data and workflows. PIC captures all activities occurring within the PIC device's active view. This stream data will be captured, processed, and converted into digital data for analysis and sharing (see Fig. 1 and 2).

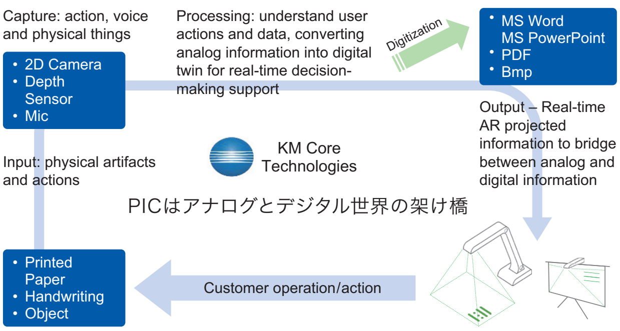

Fig. 1 High level concept of PIC.

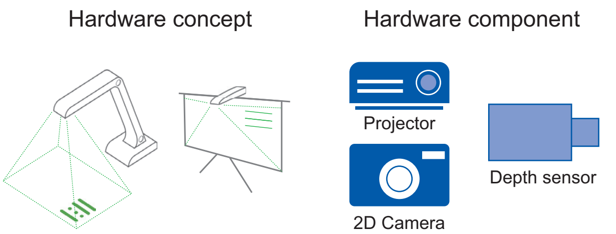

Fig. 2 Components of PIC.

The key technologies are 1. Masking images between projected information and physical drawing, 2. Change detection under PIC device and 3. Digitization. Fig. 3 shows the high-level block diagram of PIC's key technologies.

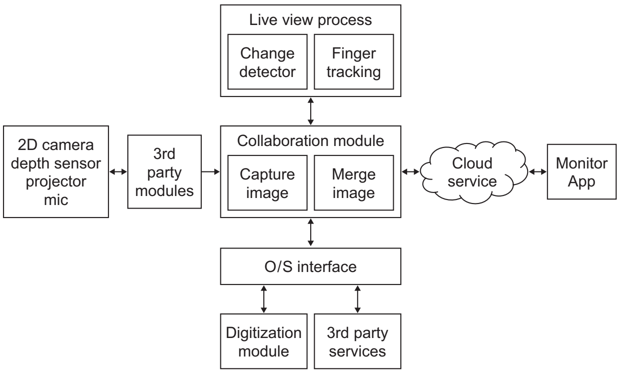

Fig. 3 High level PIC block diagram.

SLD leverages some 3rd party libraries and services, however, we develop key core functions, such as the change detector, image masking and digitization modules Since the collaboration session is communicating with remote devices, we use a 3rd party messaging system on a Cloud server, and run our collaboration software applications on many platforms (including browser based).

2. 1 Image masking technology

Fig. 4 shows the raw image from a PIC that includes both locally (physically) written contents and projected content from a remote device. When a user at the PIC device physically writes something, PIC captures the image within the PIC active view and sends it to remote devices that are being collaborated with. Before sending this information, any projected content needs to be removed from the image sent to the remote device. Otherwise, content from other users would be captured and sent, causing incorrect information artifacts (mirror-in-mirror issue). Additionally, this pre-processing minimizes the amount of transferred data, resulting in a more responsive user experience. Fig. 5 shows the cropped/cleaned image with mask generation data (created to mask any projected information).

Fig. 4 Raw image captured including both projected content from remote device and locally written content.

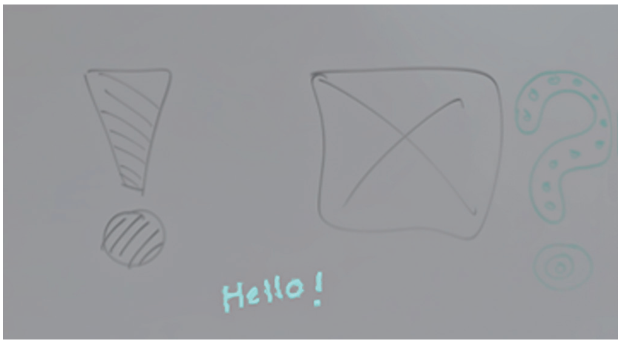

Fig. 5 Cropped, rotated and cleaned overlayed with mask generation for projected content (shown in blue).

Finally, Fig. 6 Shows the final data to send to the remote devices. The image is cleaned and the background and projected information has been removed.

This approach allows PIC to efficiently send real-time, artifact free, collaboration information without the need of expensive hardware assists.

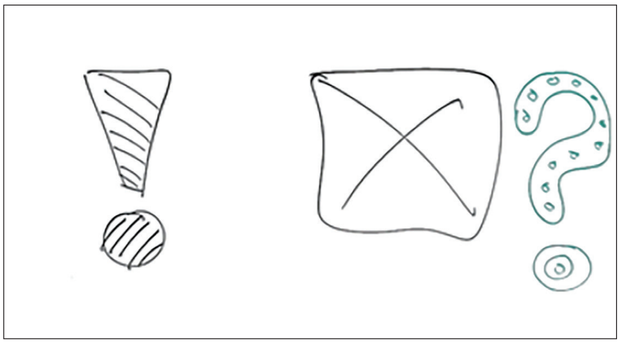

Fig. 6 Final output image to the remote device after removing projected content.

2. 2 Real-time change detection technology

SLD developed a change detection module to only send user updated data, therefore, improving data transfer efficiency in this real-time collaboration system. The key aspect of the collaboration with PIC is seamless real-time collaboration, so whenever a user creates new content, it should be immediately reflected on the remote devices. Therefore, PIC needs to monitor the activities within its active view. In its current configuration, the change detector module divides the PIC active view into 6 × 8 small tiles/regions and monitors the status in each tile (see Fig. 7.) By monitoring the small tiles, the processing data size can be minimized because PIC only checks and processes the changed tile(s).

Fig. 8 shows an example where the change detector only processes the tiles that have changed status from the previous frame in Fig. 7. The foreground image is precisely identified, and the algorithm (leveraging the open source OpenCV Adaptive Threshold method) calculates the center of mass.

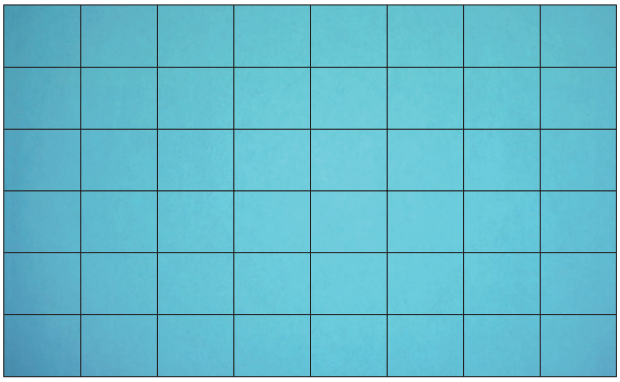

Fig. 7 PIC active view divided into 6x8 small tiles.

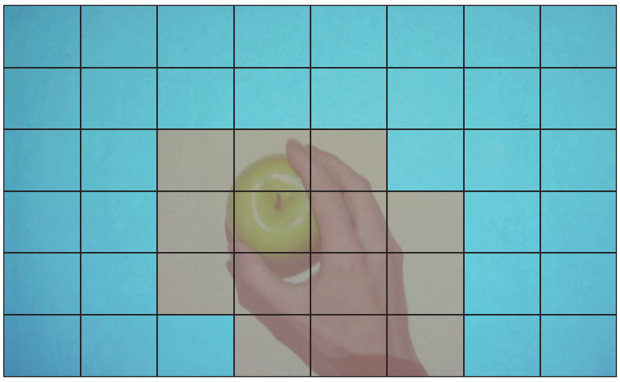

Fig. 8 Red highlighted tiles are regions that have changed status from the previous frame.

Fig. 9 shows a frame image with the center of mass overlay. Fig. 10 shows the subsequent frame captured by PIC with a calculated change for center of mass. Once a state has not changed for the last two frames (based on negligible center of mass changes between frames), the change detector module recognizes the tile as stable and sends the tile data to the remote devices.

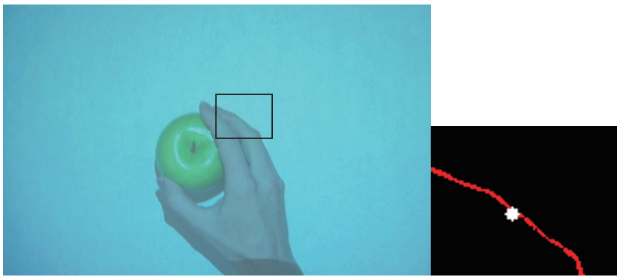

Fig. 9 Frame image of objects with center of mass overlay (small rectangle).

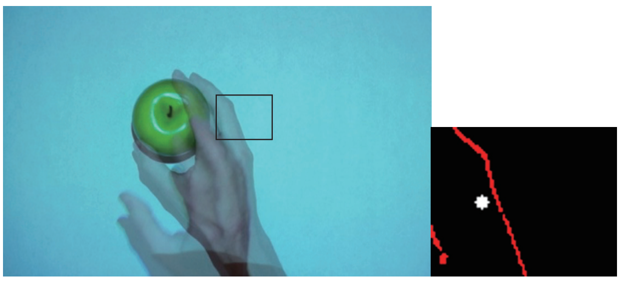

Fig. 10 Subsequent frame image with updated center of mass overlay.

2. 3 Digitization technology

After the collaboration session ends, users want to share the contents with others, but if the output content is just a bitmap, it is less useful to the users because it is not editable or searchable. Therefore, SLD developed a conversion module to convert from bitmap image to Microsoft Word/PowerPoint and Adobe PDF. Usually with today's bitmap conversion software, it is not possible to convert handwritten text into typeface text. Our module can perform conversion of handwritten text (ICR) as well as conversion of objects into their intended form (Table, Flowchart, Vector and Shape).

Fig. 11 shows the basic workflow for our conversion module. We use Machine Learning and Heuristic models to classify the content types (e.g., Text, Table, Vector, Shape and Flowchart).

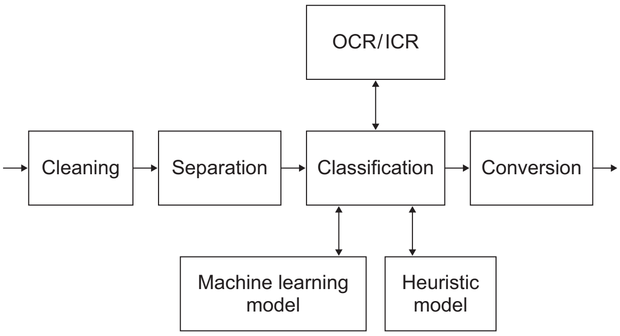

Fig. 11 Digitization process diagram.

Fig. 12 shows an example of handwritten content. It contains a variety of objects with the intended forms of Text, Shape, Table, Flowchart and Vector

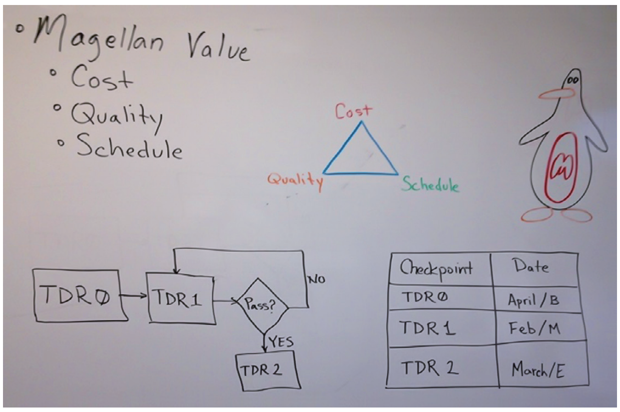

Fig. 12 Example of handwriting content.

Fig. 13 shows the classified regions from the classification module. The orange rectangle indicates a text region, green rectangle → shape region, blue rectangle → flowchart region, red rectangle → table region, and purple rectangle → vector region

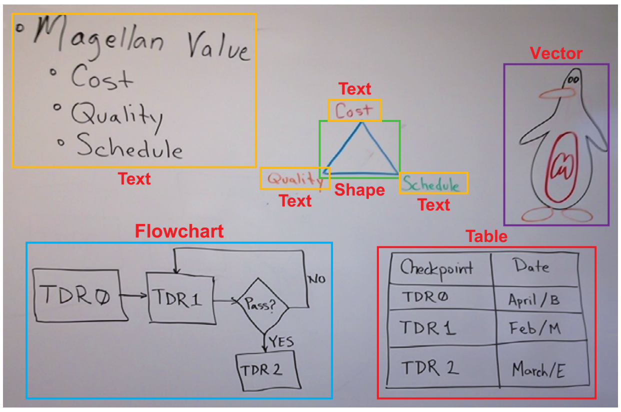

Fig. 13 Example of classification for Fig. 12.

Fig. 14 shows the final output from SLD's conversion module into a Microsoft PowerPoint file. All objects are correctly converted into their intended, native, editable form. The user can modify the PowerPoint file contents and share with other participants. In addition, the native objects allows easier searching for content within the files, enabling other useful workflows to retrieve content from meetings that would have been lost if information was maintained in bitmap form.

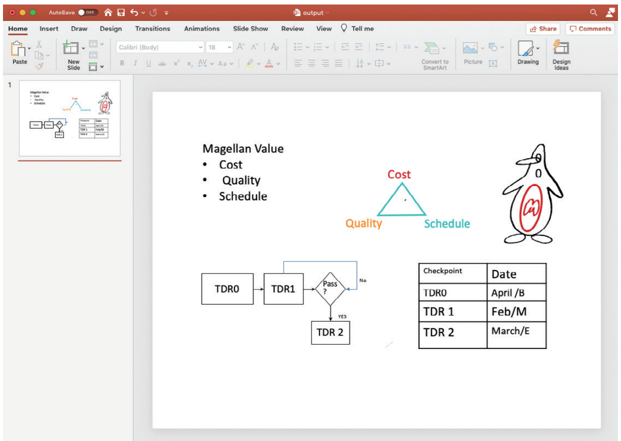

Fig. 14 Example of PowerPoint output from Fig. 12 example.

3 Conclusion

DX is an important mission for many companies, including Konica Minolta, yet its progress is slow due to many challenges. A primary challenge is the high hurdle to change user workflows. PIC can reduce the hurdle many companies struggle with because it does not require the user to change their preferred analog workflows. By seamlessly bridging between analog and digital workflows, PIC enables a unique solution for people who use physical objects as part of their collaboration but struggle to work in a remote environment due to the Covid-19 pandemic.