様式 7

論　文　内　容　要　旨

| 報告番号 | 甲　先　第　190　号 | 氏　名 | Ahmed Ibrahim Elhossany Elmarhomy |
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| 学位論文題目 | A Method for Real Time Counting Passersby utilizing Space-time Imagery<br>（時空間画像を用いた実時間通行人数計測手法） | | |

内容要旨

People counting is a process used to measure the number of people passing by a certain passage, or any marked off area, per unit of time; and it can also measure the direction in which they travel. Manual counting is one of the conventional methods for counting people. People can simply count the number of people passing a confined area by using counter. Although people can count accurately within a short period of time, human labors have limited attention span and reliability when large amount of data has to be analyzed over a long period of time, especially in crowded conditions. Every day, a large number of people move around in all directions in buildings, on roads, railway platforms, and stations, etc. Understanding the number of people and the flow of the persons is useful for efficient promotion of the institution managements and company's sales improvements.

On the other hand, most of the deficiencies of manual counting could be handled through automatic people counting systems. In such systems, counting is performed through many approaches among which are a real-time image processing approach. Where a video camera is used to capture video sequences of crossing people and export them to a software package for being processed and interpreted. Counting people and track objects in a video are an important application of computer vision. Computer vision is the science and application of obtaining models, meaning and control information from visual data. It enables artificial intelligence systems to effectively interact with the real world.

Counting people approaches using fixed cameras in image processing techniques can be separated into two types. The first one is an overhead camera that counts the number of people crossing a pre-determined area. The second is count people based detection and crowd segmentation algorithms. In the overhead camera scenario, many difficulties that arise with traditional side-view surveillance systems are rarely present. Overhead views of crowds are more easily segmented compared with a side-view angle camera that can segment as one continuous object.

This thesis proposes a method to automatically count passersby by recording images using virtual, vertical measurement lines. The process of recognizing a passerby is performed using an image sequence obtained from a USB camera placed in a side-view position. While different types of cameras work from three different viewpoints (overhead, front, and side views), the earlier proposed

methods were not applicable to the widely installed side-view cameras selected for this work. This new approach uses a side view camera that faced and solved new challenges: (1)two passersby walking in close proximity to each other, at the same time, and in the same direction; (2) two passersby moving simultaneously in opposite directions; (3) a passerby moving in a line followed by another, or more, in quick succession.

This thesis introduces an automated method for counting passerby using virtual-vertical measurement lines. The process of recognizing a passerby is carried out using an image sequence obtained from the USB camera. Space-time images are representing the time as a pixel distance which is used to support the algorithm to achieve the accurate counting. The human regions treated using the passerby segmentation process based on the lookup table and labeling. The shape of the human region in space-time images indicates how many people passed by.

To handle the problem of mismatching, different color space are used to perform the template matching which chose automatically the best matching. The system sing different color spaces to perform the template matching, and automatically select the optimal matching accurately counts passersby with an error rate of approximately 3%, lower than earlier proposed methods. The passersby direction are 100% accuracy determined based on the proposed optimal match.

This work used five characteristics: detect the position of a person's head, the center of gravity, human-pixel area, speed of passerby, and distance between people. These five characteristics enable accurate counting of passersby. The proposed method does not involve optical flow or other algorithms at this level. Instead, human images are extracted and tracked using background subtraction and time-space images. Moreover, a relation between passerby speed and the human-pixel area is used to distinguish one or two passersby.

In the experiment, the camera is fixed at the entrance door of the hall in a side viewing position. PC is connected to the camera with a frame rate 17 frame per second. The proposed method was tested with 50 cases in each situation. In addition to more than 40 short captured video about 5 minutes series of video sequences of various scenarios and also tested with 9 long captured video. Finally, experimental results verify the effectiveness of the presented method by correctly detecting and successfully counting them in order to direction with accuracy of 97%.

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論文審査の結果の要旨

| 報告番号 | 甲　先　第　１９０　号 | 氏　名 | Ahmed Ibrahim Elhossany Elmarhomy |
|---|---|---|---|
| 審査委員 | 主査　福　見　　稔<br>副査　獅々堀　正　幹<br>副査　寺　田　賢　治 | | |

学位論文題目

A Method for Real Time Counting Passersby utilizing Space-time Imagery
（時空間画像を用いた実時間通行人数計測手法）

審査結果の要旨

セキュリティやマーケティング調査のために，道路やロビー，通路などにおいて通行人数を計測する需要は多い．現在，それはカウンター片手に人が行なっているが，長時間にわたる実施が難しい，一度に多く通る場合など精度が落ちる，人が配置しにくい場所などがある，などの問題がある．またゲートやバーなどの装置を使って計測することとも考えられるが，コストがかかる，設置場所が限定される，通行の妨げになるなどの問題があり，応用が一部に限られている．その解決方法のひとつとして，カメラ画像を用いた人数計測方式が有力であると言われている．しかし，これまでに提案されている画像処理による人数計測法は，追跡処理などを必要とするため，人数が多い場合に処理ができなくなる，また人と人が重なった場合などに正しい追跡ができなくなるなどの問題があった．そこで本研究では，複数の計測線を用いた新しい画像処理による人数計測法を提案した．これは，カメラ上に仮想的に設定した計測線により生成される時空間画像を用いた人数計測手法で，通過人数を計測するための時空間画像と，方向や速度，もしくは重なった人の計測精度を低減を緩和する複数個の時空間画像より構成される．本手法ではまず天井や壁などに設置されたカメラから画像を連続的に取得する．そして画面上に設定された複数の計測線より時空間画像を生成する．そして時空間画像上の人の分布を計測することで通行人数を計測し，時空間画像間の人の分布の関係を見ることで，各々の人の進行方向と通行速度を求め，複数個の時空間画像の中から最も良いものを選択することで，人同士の重なりによる計測の見逃しを低減する．すなわち本手法では，時空間画像を用いることで，人の追跡をすることなく，人数を計測することを可能にし，複数個の時空間画像を用いることで，正確な進行方向と歩行速度を求めることが可能となった．

以上本研究は，コンピュータビジョン分野において新しい手法を提案し，様々な実験を通して有効性を確認したもので一定の水準に達するものであり，本論文は博士（工学）の学位授与に値するものと判定する。