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PECULIARITIES OF ORGANIZATION OF CONTROL UNIT FOR THE SYSTEM OF 2D IMAGES RECOGNITION

The paper contains structural diagram of images recognition for determination of their symmetry by instantaneous features. Special organization of control unit, which performs not only control functions but preprocessing of images. The results of synthesis of PLIC-based control unit are presented.

Key words: *image recognition, control unit, analyzer*

INTRODUCTION

Theoretical fundamentals, methods and recognition algorithms are widely used for solution of various problems dealing with automation of manufacturing processes including technological robotic complexes [1] . High degree of recognition probability, first of all, depends on the correct organization of tightly interconnected sensing and intellectualization systems. The aim of development of flexible robotic complexes is to create efficient sensor systems and information processing algorithms. Information, required to perform this task, is provided by sensing system – the most important subsystem of adaptive robot, in its turn, the system of technical vision (STV) is the source of information for sensing system.

Since STV provides high information content relatively sensing, analysis and processing of the image, then the sphere of application of such systems is rather wide: automation of assembly operation, visual control, non-destructive testing of parts and blocks, etc [2-4].

In general case, each STV represents certain hierarchial level with stricktly defined characteristics. Application of adaptive control considerably improves structural and functional organization of STV and is one of the main directions of enhancement its intelligence abilities due to: a) providing simultaneous processing of large volumes of information; b) formation of command in real-time mode; c) modeling of operation processes intended for elaboration of control systems self-learning methods.

Thus, control system performs greater part of work dealing with “intellectualization” of STV. The aim of the given research is the optimization of control unit for image recognition system by its geometrical characters, central and axial symmetry of object images being used as these characters.

Problem set-up.

Features used for object identification, the application of which is connected with the necessity of performing large volumes of computational procedures and, hence, large capacity of ROM and other types of memory are the determining factors, applied to perform STV functions in real-time mode.

Application of various algorithms enabling to create references at the stage of teaching in order to determine object position or peculiarities (symmetry) of the object itself is very productive approach in elaboration of STV for industrial robots. Samples of images but not separate features can be used as references, for identification of these samples the overlapping of the image on the sample is performed. In common case, the procedure comprises the combination of image analysis results or their geometrical peculiarities [1-5].

In the given paper special attention is paid to peculiarities of symmetric objects recognition by their instantaneous features with formation of object references [6-9]. The process of formation of resulting signals classification of object input images comprises the following recognition stages [Fig 1]

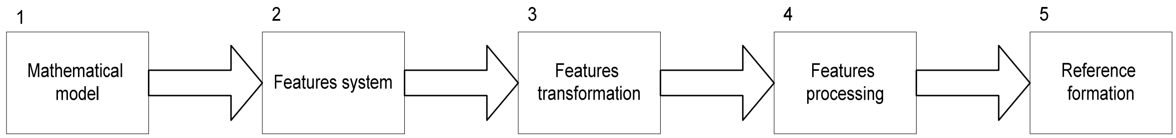

Fig. 1.Stages of recognition

It is known that the approach to the selection of image mathematical model involves the method of image description, the more universal the method of description of the image is, the easier is the method of allocation of features system, which contain the information about the image [8, 10-13]. The source of information of STV vision field is light flux, which in the given case is described by brightness function. Therefore, at the output of image formation system videosignal emerges, corresponding to the brightness of the object, being in vision field. That is why the function of such "intellectualization" is the combination of image processing procedures by optical units, formation of corresponding signals by control unit, taking into account certain peculiarities (symmetry) of the image [14-15]. In any engineering development these features must be transformed into the form, convenient for input videosignal processing and formation of references. For this purpose initial and repeated alignments are preliminary performed by instantaneous features, realized by means of the method of symmetric images of the object recognition, diagram of which is shown in Fig 2.

The procedure, presented in each operating peak of the given diagram, corresponds to macrooperation, realized in recognition system [14, 15]. Initial alignment enables to determine the centre of gravity of the object. Secondary alignments increase the totality of features for formation of the given symmetry reference.

Introduced image of the object in initial orientation (operator 1) is formed as the light flux. The light flux is multiplied and divided into two equal streams (operator 2) and is treated along two channels. For this purpose, each of light streams being multiplied is sent across shade binary masks, performing spatial modulation of the image (operator 3). Modulation is performed by means of shade masks complex facilitating the execution of the initial alignment (operator 4), i.e., determination of weighted sums of image intensities and their comparison (operator 5). If weighted sums of image intensities are equal (operator 7), certain information, corresponding to references of symmetry grades is fixed. Otherwise image shift (operator 6) is performed, determining additional features required for formation of definite reference of image symmetry. The second stage of image processing (repeated alignments) is performed by operators 8-16. For initially introduced image necessary orientation is fixed, i.e., turning angle equals $\varphi=0$ (operator 8).

Transformation procedures, performed by operators 9-13 are similar to procedures (operators 2-6) and differ only by the fact that after initial alignment other sets of masks are introduced (operator 10), image rotation (operator 15) is performed within the angle $0\ldots\pi/2$, masks sets being fixed (operator 16)necessary for execution of repeated alignments.

Execution of initial and repeated alignments allows to perform their transformation and processing on the basis of selected system of instantaneous features, with further formation in the form of resulting signals (operator 17), corresponding to the reference of the image being recognized.

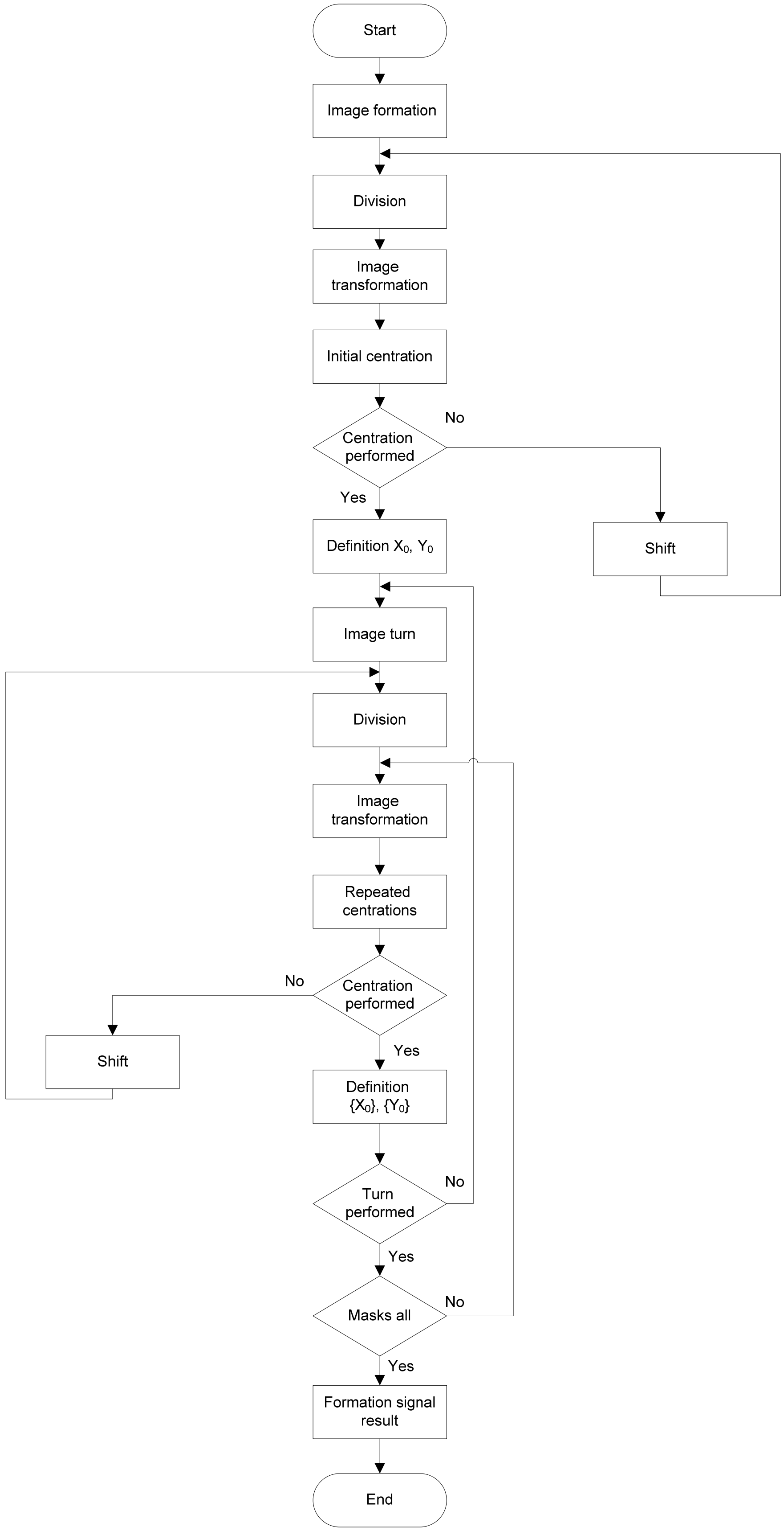

Fig. 2 Block-diagram of recognition algorithm .

Structure of image recognition device

The system, realizing the formation of symmetric images references in the process of their recognition comprises optical processing unit (PU), that contains the first alignment shift unit with projection optics, image turn unit, the second alignment shift unit, channels of images processing, each containing light flux multiplicator, generator of static signals moments and control unit (Fig 3).

The operation of the system begins with sending “start” signal at the control unit, where input values, namely, N – number of columns; M – number of image shift rows; L – number of image turns; K – number of mask sets are written by corresponding buses.

Control unit, at corresponding output, at first forms addresses in shade masks sets change units, which correspond to definition and balancing of static moments of the first order. After completion of initial alignment in two generators, the precise addresses of mask sets, unambiguously corresponding to definition and balancing of static moments of higher orders will be sent by the control unit to perform repeated alignments.

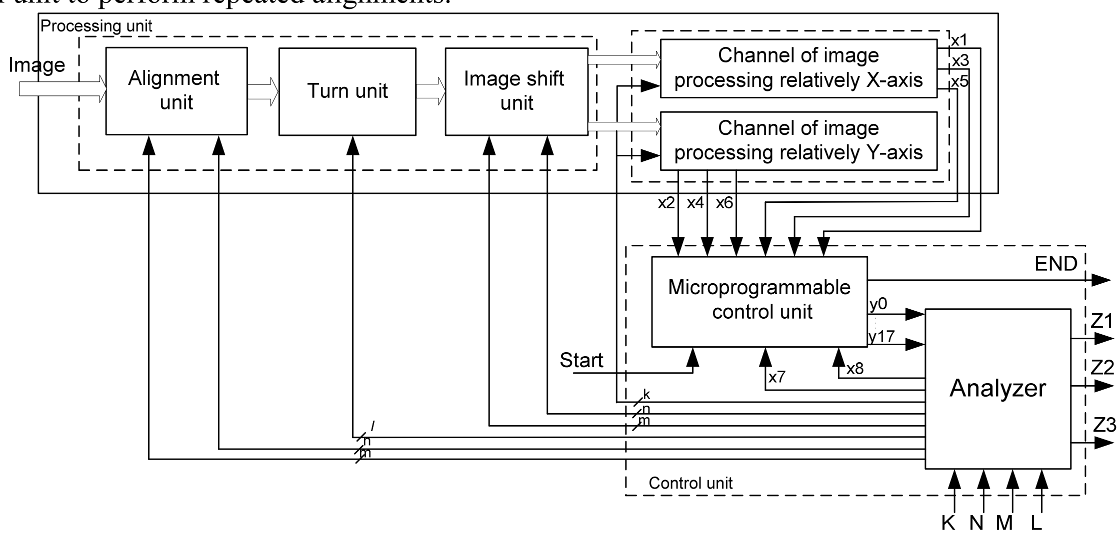

Fig. 3 Structural diagram of recognition system

The system enables to process binary and half-tone images, for which brightness ranges of input image have central symmetry (if central-symmetrical image is recognized) or axial symmetry (image with axial symmetry).

If the information carrier regarding the image is the lens or reflector, then acoustooptic reflectors or devices for shift signal control can be applied [16].

Optic connections between the units of the installation (between the first shift unit with projection optics, unit of image rotation, the second shift unit, between outputs of the multiplicator, unit of masks change and optical converters) can be realized by direct optic connection and matching of their inputs or by means of fiber-optic communication channels with the help of fiber-optic braids [17-18]

Principle of operation and control unit organization

The characteristic feature of control unit for the given system is the possibility of the unit not only to perform control functions but also to preprocess information regarding input videosignal, as a result symmetry features of the image are formed.

Control unit (Fig 3) consists of two parts: microprogrammable control unit MPCU (Fig 4) and analyzer of object symmetry (Fig 5). Microprogrammable control unit comprises (Fig 4) the following basic components: programmable ROM, register RZ, decoders DC, clock-pulses generator, trigger T and logic elements, analyzer (Fig 5) contains six counters C, decoder DC, for RAM microcircuits, two comparators COM, three triggers T and logic elements.

Division of control unit structure into two functionally-independent devices, MPCU and analyzer, is due not only to specificity of application in systems of MV but also by the necessity of reprogramming the control unit in the process of expansion of functional possibilities of recognition system.

The structure and technique of MPCU synthesis are well known [19,20]. Besides, mcroprogrammable devices are, to some extent, invariant to the specific features of the given algorithm designed for data processing, since they deal with its graph-diagram [21.22]

Thus, the organization of analyzer, as the part of control unit, oriented at realization of certain algorithm of image recognition is of great interest for the given research. Let us consider the specific features of structural organization and operation principle of analyzer, which is connected with processing and analysis of symmetric images in the devise [23, 24].

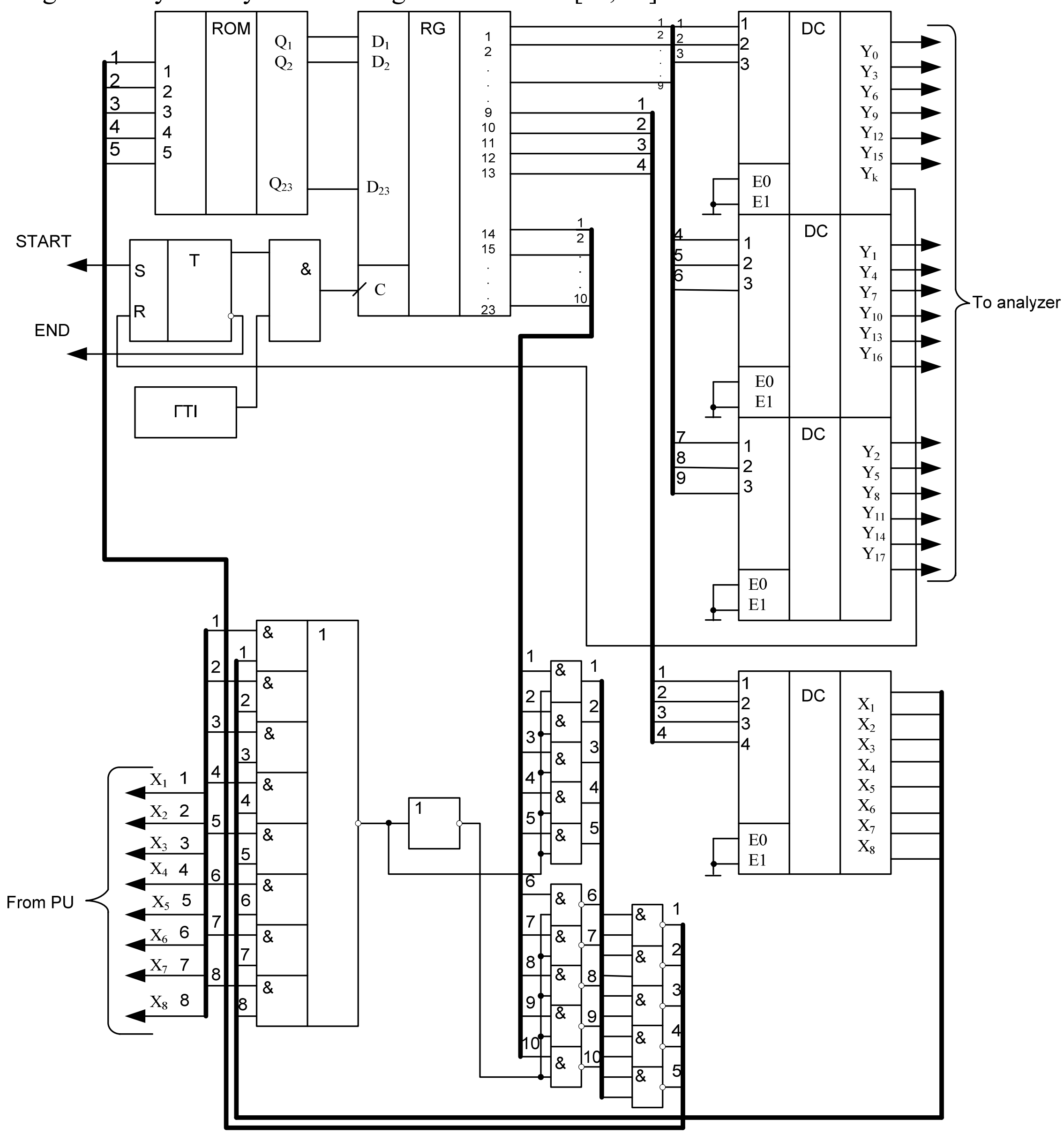

Fig. 4 Microprogrammable control unit

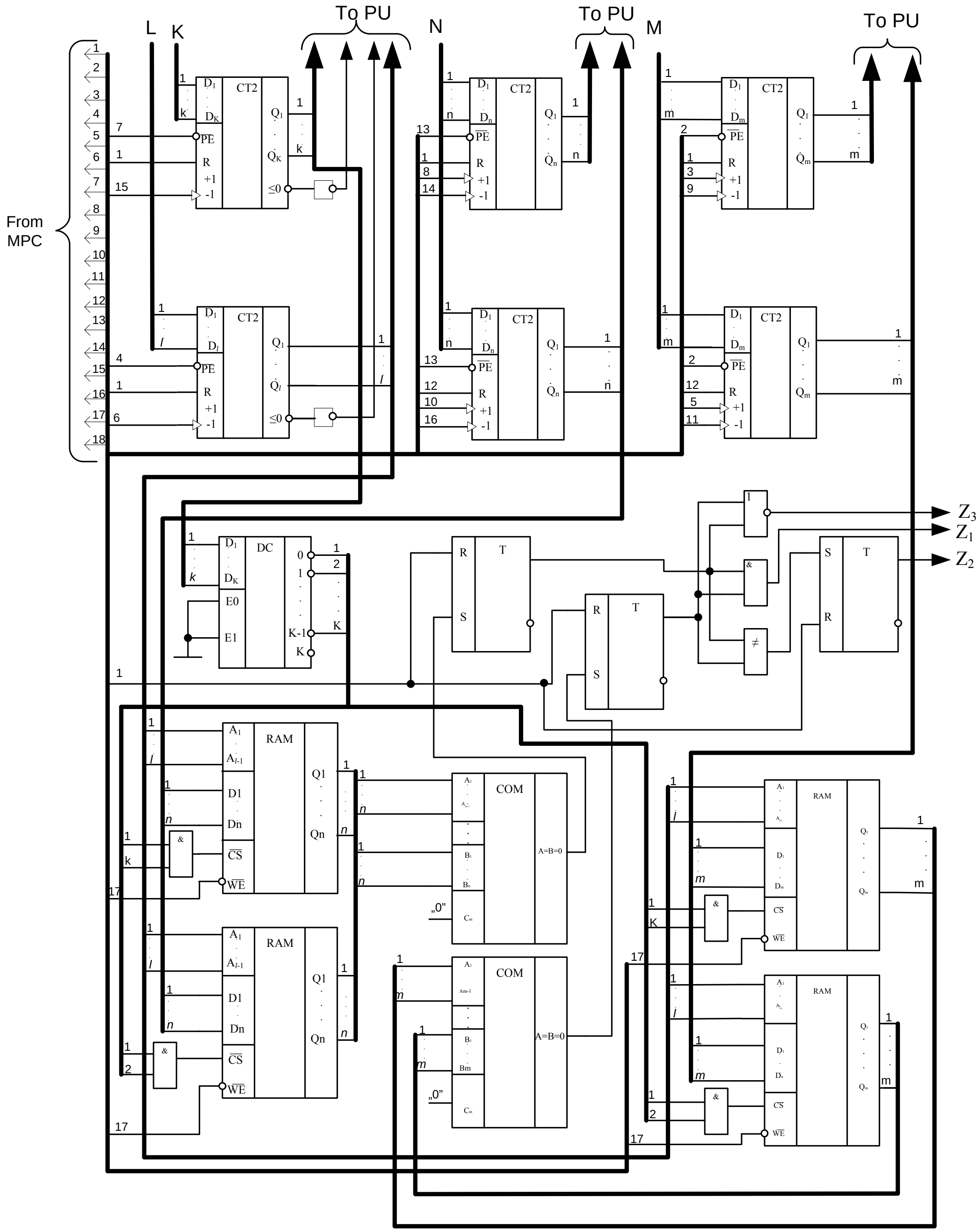

Fig. 5 Analyzer of object symmetry

In analyzer of object symmetry (Fig. 5) six counters operate in the following manner: one of the counters is used for organization of replacement cycle of i-th set of shade binary masks; the second counter is the counter of turns number, initially the value L=90/Δφ is input into the counter, Δφ - turn step, the given counter is used for organization of image rotation cycle; the third and fourth counters registrate the coordinates of counting point Al (xl, y1) of the image along axes X and Y accordingly in the process of initial alignment of basic image; the last two counters registrate values Δxl, Δx2,... Δxk-1, and Δyl, Δy2,... Δyk-1 of image shift along axes X and Y accordingly in the process of repeated alignments of initial image.

Four RAM circuits are used for storage of shift value along axes x and y accordingly for masks sets while determining turn angle, the address of masks set serving for the selection of required RAM microcircuit and the address of turn angle is the address, where corresponding information is recorded from the counters into RAM.

Output signals for analyzer are the resulting signals Zl, Z2, Z3:

- single value of Zl signal certifies central symmetry of the image;
- single value of Z2 signal certifies axial symmetry of the image;
- single value of Z3 signal certifies asymmetry of the image.

Control unit [Fig 3], divided into two functionally-independent blocks: MPCU and analyzer, enables each of these blocks to synthesize separately being oriented to perspective element basis-PLIC.

In [25] the realization of MPCU on R-automata with unit coding of its states, the structure of these automata is optimal for usage of PLIC architecture MPCU scheme is not complicated, that is why, the choice of PLICs is rather wide. For the given case PLIC of ALTERA company MAX 7000(E)S was chosen, free of charge full functional CAD MAX+PLUSII is available. Results of MPCU circuit simulation (Fig 4) applying CAD proved the possibility of its realization in a single housing with PLIC MAX7000(E)S.

The structure of analyzer comprises such components as decoders, counters, memory blocks. The majority of PLICs contain libraries of such macroelements, that considerably reduces the time, needed for their programming.

But the main problem of analyzer scheme realization is the application of RAM elements, that is why, it is expedient to divide the scheme of analyzer into two parts: one of them consists of such basic elements as decoders and counters, the second one - circuits of comparators and RAM [24].

While selection of PLIC for modeling analyzer scheme, those structures which realize internal memory will be of great interest of the given research since one of the most important characteristics of the analyzer is speed parameter then the most optimal structure to be used is the PLIC-structure manufactured by ALTERA company, because this company in the process of PLIC manufacturing realizes the approach based on application of built-in, large modules of memory having reconfigurable structure. While modeling analyzer scheme it would be expedient to realize each part of analyzer in separate housings of PLIC. As a result, such "location" of analyzer scheme on PLIC FLEX 10K of ALTERA company allowed to use only two ICs [24].

Conclusions

Realization of initial alignment by statistical moments of the first order using only one set of shade masks in known devices allows to determine only one point-centre of gravity of object image. In the suggested recognition system the execution of initial and repeated alignments gives the possibility to determine not one but a definite number of points, analysis of their coordinates allowing to create classification features of symmetry [27].

Formation of one of three resulting signals (Zl, *72,* Z3) corresponding to the feature of central axial symmetry or asymmetry of object images, proves the possibility of classification of input 2D images by three classes of symmetry [28]. In order to perform recognition operation relatively reference coordinate point Ai (x1, y1)

It is sufficient to determine only some points by means of several repeated alignments to judge about available symmetry feature relatively the centre or axial [29,30].

The peculiar feature of structure organization of control unit for the suggested system of image recognition, which performs not only the control functions but image preprocessing, predetermines its subdivision into two functionally-independent blocks: microprogrammable control unit and analyzer, which, in their turn, can be successfully realized on perspective element base-programmable locig IC (PLIC).

REFERENCES

1. Анисимов Б. В., Курганов В. Д., Злобин В. К. Распознавание и цифровая обработка изображений. – М.: Высшая школа, 1983. – 295 с.
2. Куафе Ф. Взаимодействие робота с внешней средой: Пер. с франц. – М.: Мир, 1985. – 285 с.
3. Путятин Е. П., Аверин С. И. Обработка изображений в робототехнике. – М.: Машиностроение, 1990. – 318 с.
4. Генкин В. Л., Ерош И. Л., Москалев Э. С. Системы распознавания автоматизированных производств. – Л.: Машиностроение. Ленинградское отделение, 1988. – 246 с.
5. Системы очувствления и адаптивные промышленные роботы / Под общей ред. Е. П. Попова и В. В. Клюева. – М.: Машиностроение, 1985. – 256 с.
6. Буда А. Г., Мартынюк Т. Б., Лищинская Л. Б. Структурный переход от исходных признаков к результативным на этапах предварительной обработки изображений // Науково-технічна конференція „Приладобудування – 96”. Ч. 1. – Винница – Судак, 1996. – С. 127.
7. Буда А. Г., Мартынюк Т. Б. Конструирование моментных признаков на этапах распознавания классов и подклассов изображений // 3-я Українська конференція з автоматичного керування "Автоматика – 96". – Севастополь: СевГТУ, 1996. – С. 156 – 157.
8. Буда А. Г. Розробка моделей та дослідження прикладних методів обробки геометричних зображень на підставі моментних характеристик: Автореферат дис... канд. тех. наук: 05.13.16 / Вінниц. політехн. ін-т. – Вінниця, 1993. – 23 с.
9. Буда А. Г., Мартинюк Т. Б., Кожем’яко А. В. Створення еталонів класів та підкласів зображень на підставі моментних ознак // Праці третьої Всеукраїнської міжнародної конференції „УкрОБРАЗ – 96”. – Київ, 1996. – С. 79 – 81.
10. Buda A., Martyniuk T., Buda S. Methods of representation of the symmetric images in devices of recognition, in Selected Paper from the International Conference on Optoelectronic Information Technologies, Proceeding of SPIE/ Vol. 4425 (2001), P. 70 – 75.
11. Буда А. Г., Мартинюк Т. Б., Кормановський С. І., Король О. В. Базис геометричних ознак зображень та особливості їх застосування // Матеріали МНПК „Сучасні проблеми геометричного моделювання”. – Львів, 2003. – С. 162 – 166.
12. Буда А. Г., Мартинюк Т. Б. Ознаковий простір моментних характеристик при розпізнаванні класів і підкласів симетричних зображень // Вісник ВПІ. – 2007. – №1. – С. 61 – 66.
13. Буда А. Г., Мартинюк Т. Б., Король О. В. Створення множини ознак при аналізі правильних зображень // Праці восьмої Всеукраїнської міжнародної конференції „УкрОБРАЗ – 2006”. – Київ, 2006. – С.111 – 113.
14. Патент України №3741, кл. G06K9/58, G06K9/52 Спосіб розпізнавання симетричності зображень об’єктів і пристрій для його реалізації/ В. П. Кожем’яко, В. Г. Красиленко, Т. Б. Мартинюк, А. Г. Буда. – №93321261; Заявлено 16.03.93; Опубл. 27.12.94, Бюл. № 6 – 1. – 35 с.
15. Патент України 52678, кл. G06K9/00, G06K9/58, G06K9/52. Пристрій для розпізнавання симетричності зображень об’єктів/А. Г. Буда, Т. Б. Мартинюк, А. В. Кожем’яко, В. І. Андрущенко. – № 99021033; Заявлено 23.02.99; Опубл. 15.01.2003, Бюл. № 1. – 32с.
16. Семенов А. С., Смирнов В. Л., Шмалько А. В. Интегральная оптика для систем передачи и обработки информации. – М.: Радио и связь, 1990. – 224 с.
17. Волоконно-оптические системы передачи информации и кабели : Справочник / И. И. Гроднев и др. – М.: Радио и связь, 1993. – 246 с.
18. Кожем’яко В. П., Павлов С. В., Мартинюк Т. Б., Лисенко Г. Л. Волоконно-оптичні структури комутації та передачі інформації. Навч. посібник. – Вінниця: ВДТУ, 2002. – 106 с.
19. Каган В. М. Электронные вычислительные машины и системы: Учеб. пособие для вузов. – М.: Энергоатомиздат, 1991. – 592 с.
20. Апраксин Ю. К. Теория и проектирование ЭВМ. Синтез управляющих автоматов: Учебное пособие. – К.: ІСДО, 1993. – 80 с.
21. Баранов С. И. Синтез микропрограммных автоматов – Л.: Энергия, 1979. – 216 с.
22. Арсеньев Ю. Н., Журавлев В. М. Проектирование систем логического управления на микропроцессорных средствах: Учебное пособие. – М. : Высшая школа, 1991. – 319 с.
23. Мартынюк Т. Б., Кожемяко А. В., Вербицкий И. А, Фофанова Н. В. Реализация анализатора симметричности изображений в элементном базисе ПЛИС FLEX 10K // Вимірювальна та обчислювальна техніка в технологічних процесах: Збірник наукових праць. – Хмельницький: ТУП, 2001. – Вип. № 8 (2001) – С. 55 – 58.
24. Буда А. Г., Мартынюк Т. Б., Лысенко Г. Л. Техническая реализация признаков, полученных на основе исследования функциональных характеристик // Оптико-електронні інформаційно-енергетичні технології. – 2002. – № 2 (4).– С. 71 – 77.
25. Мартинюк Т. Б., Фофанова Н. В., Шеляков О. Л. Реалізація блока керування на R-автоматі в елементному базисі ПЛІС // Вісник ВПІ. – 2002.- №2. – С. 51 – 55.

26. Лисенко Г. Л., Мартинюк Т. Б., Фофанова Н. В. Особливості реалізації в елементному базисі ПЛІС мікропрограмних R- автоматів // Вісник ЖІТІ. Спецвипуск. – 2002. – С. 203 – 206.

27. Буда А. Г., Мартынюк Т. Б., Буда С. А. Методы представления симметричных изображений в устройстве распознавания // Збірник тез доповідей МНТК „Оптоелектронні інформаційні технології. Photonics – ODS2000”. – Вінниця: „Універсум-Вінниця”, 2000. – С. 37 – 39.

28. Буда А. Г., Мартынюк Т. Б., Король О. В. Алгоритм сжатия изображения и его классификационные признаки // Збірник наукових праць „Геометричне та комп’ютерне моделювання”. Вип. 8. Харківський державний универсистет харчування та торгівлі. – Харків, 2005. – С. 205 – 210.

29. Буда А. Г., Мартинюк Т. Б., Лисенко Г. Л., Король О. В., Буда С. А. Математичні моделі аналізу контурів плоских симетричних зображень // Праці П’ятої Всеукраїнської міжнародної конференції „УкрОБРАЗ – 2000”. – Київ, 2000. – С. 221 – 222.

30. Буда А. Г., Мартинюк Т. Б. Король О. В. Створення модифікації математичної моделі на підставі геометричних моментів // Материалы второй украинско-российской научно-практической конференции «Современные проблемы геометрического моделирования». – Харьков, 2007. – С. 205 – 210.

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