Improvement of Camera Picture Quality

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Abstract

The N905i model that was released in November 2007 features significant improvements to its camera functions. These include; a newly developed 5.2-megapixel camera, AF (autofocusing) with face detection, double image stabilization (6-axis camera shake correction + subject blur correction) and PictMagic IV (a scene categorization type picture quality improvement function). Among these new technologies aimed at the picture quality improvement of mobile phone cameras, this paper focuses on the details of the two functions in which NEC has led its competitors, namely; double image stabilization and PictMagicIV.

Keywords

N905i, camera, 5.2 megapixels, image stabilization, 6-axis, subject blur correction
PictMagic, scene-categorization type picture quality improvement

1. Introduction

Compared to previous models the N905i (**Photo 1**) model released in November 2007 features significant improvements to its camera functions, these include a newly developed 5.2-megapixel CMOS camera (maximum pixels among FOMA (R) terminals), AF (autofocusing) with face detection, double image stabilization (6-axis camera shake correction + subject blur correction) and PictMagic IV (scene categorization type picture quality improvement function). These camera picture quality improvement technologies have been developed by NEC leading the competitors, and all of them have been incorporated for the first time in the mobile phone camera. This paper will focus on the double image stabilization and PictMagic IV (scene categorization type picture quality improvement function) among the technologies.

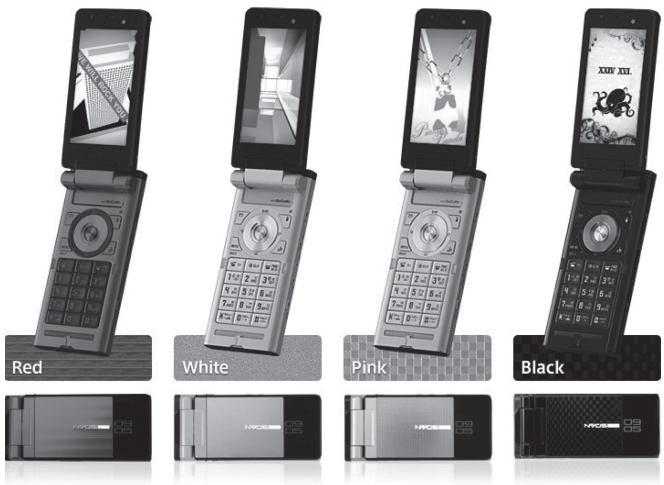

Photo 1 External views of N905i models.

2. Enhanced Image Stabilization: Double Stabilization (6–Axis Camera Shake Correction + Subject Blur Correction)

From very early on at NEC we have been developing a still image stabilization function for mobile phone cameras and have incorporated this function for the first time in Japan in the N902i. This technology compensates for camera shake, which occurs when the user holds the camera, in two directions along the x- and y-axes. The system synthesizes four images (with max. 2 megapixels) in the camera's DSP (Digital Signal Processor) (**Fig. 1**).

With the N902iS, the image stabilization accuracy was increased further by incorporating the 6-axis still image stabilization function (Super image stabilization: based on the PhotoSolid technology of Morpho, Inc.). This function adds corrections for the depthwise (z-axis) and rotational directions in addition to the horizontal and vertical (x- and y-axis) corrections (**Fig. 2**). The added capability of compensating for blur due to camera shake in the three rotational (pitch-yaw-roll) directions enables strong image stabilization that can match more scenes in actual use.

The rest of this section deals with the flow of image stabilization processing. **Fig. 3** shows a block diagram of the camera

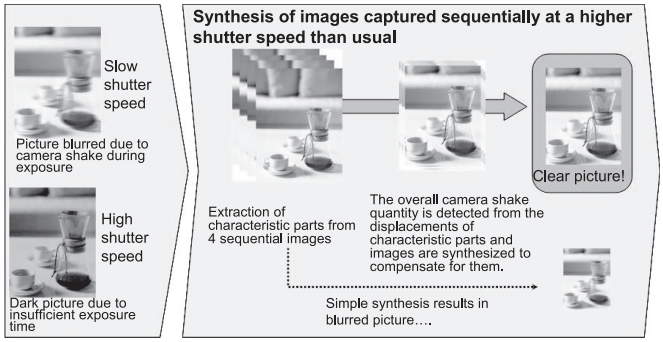

Fig. 1 Concept of image stabilization with camera shake correction.

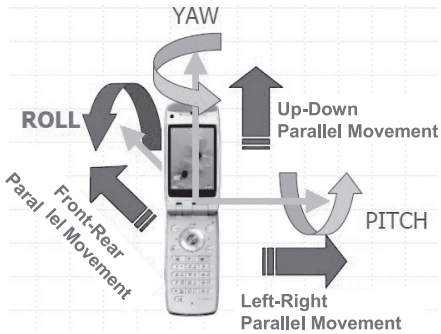

Fig. 2 6-axis image stabilization.

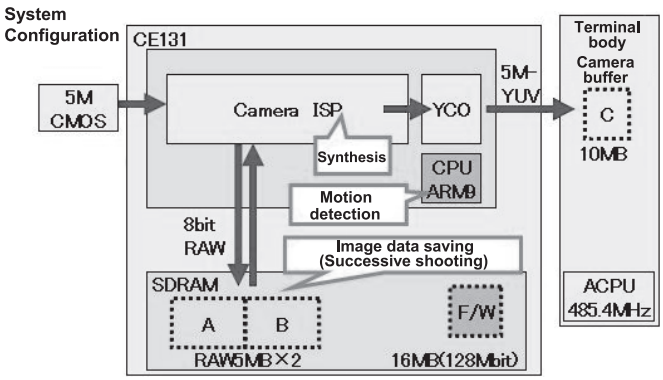

Fig. 3 Camera system block diagram.

system with traditional image stabilization based on camera shake correction.

The camera system shown in Fig. 3 is composed of the lens module with a 5M-CMOS sensor, the camera DSP (CE131) manufactured by NEC Electronics, and the application CPU (ACPU) incorporated into the mobile phone. The lens module is composed of a 5M-CMOS sensor, AF lens, an optical

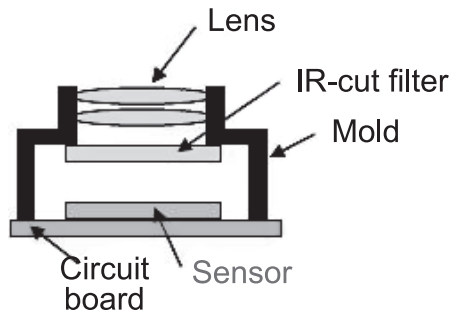

Fig. 4 Lens module configuration.

filter, PC board and mold (**Fig. 4**).

The camera DSP receives the sensor output signal (RAW data), generates the image signal from it and outputs the image data to the mobile phone terminal after applying various image processing (picture quality adjustment/correction, camera shake correction, resizing, etc.).

The ACPU incorporated in the mobile terminal controls the general camera operations according to the user interface operation (UI), receives the camera DSP output and executes its display on the LCD, image processing (PictMagicIV) and performs image saving, etc.

The image stabilization IP is provided in the FW (firmware) of the camera DSP and synthesizes the corrected picture using the 128M-bit SDRAM packaged in stack in the DSP as the buffer memory. Correction of camera shakes of a large 5-M size image is made possible around 2 seconds with high-speed processing, with which the motion detection and correction parameters extraction are executed with ARM9. The image synthesis that needs a large amount of processing is executed with the HW logic in the ISP. As shown in Fig. 1, we implemented the image stabilization by applying camera shake correction. This was done by capturing multiple images at a high shutter speed to reduce the blurs, superimposing them according to the characteristic points in the images and then synthesizing them. The synthesis of multiple images makes it possible to amplify the signal amount and reduce noise in the corrected picture.

However, the traditional method described above has been unable to superimpose the images if the subject was moving fast and the results obtained often presented ghosting. To solve this problem, we have adopted a new 6-axis image stabilization function by adding the subject blur correction capability (PhotoSolid Ver. 2 of Morpho, Inc.).

Fig. 5 explains the concept of the new subject blur correc-

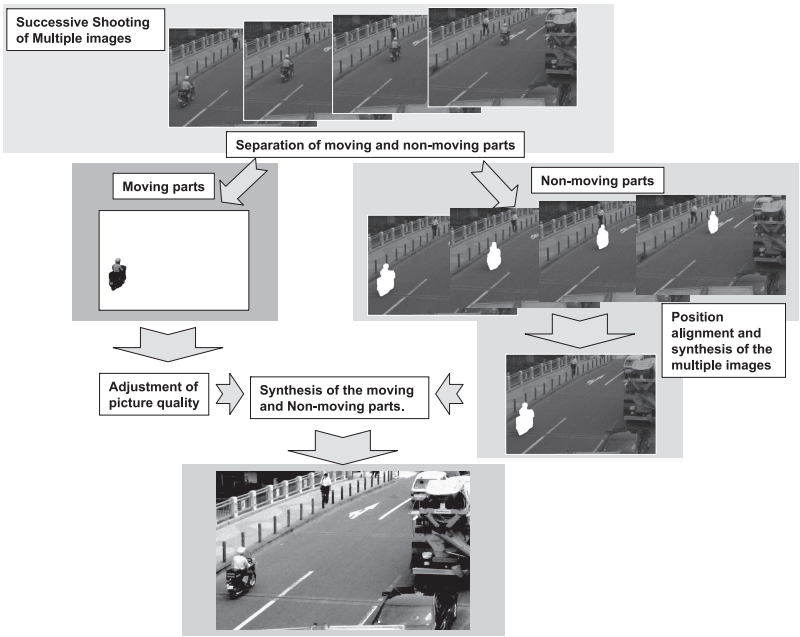

Fig. 5 Concept of subject blur correction.

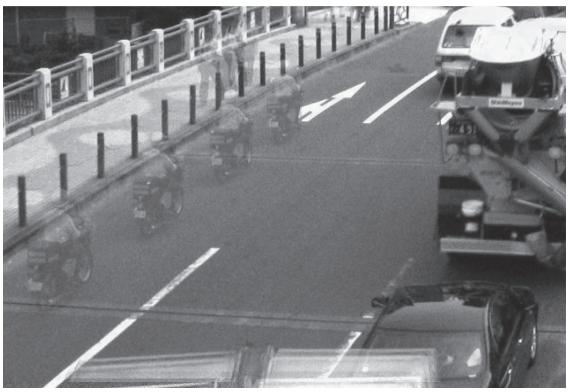

Photo 2 Example without subject blur correction.

Photo 3 Example with subject blur correction.

tion. Simply speaking, the subject blur correction is achieved by separate processing of the non-moving part of the subject (background, etc.) and the moving part.

The non-moving part of the subject is subjected to superimposed synthesis based on characteristic point extraction in order to obtain a low-noise image in the same way as for traditional image stabilization based on camera shake correction. On the other hand, the moving part of the subject is separated from the non-moving part and is not superimposed to prevent it from being disturbed by ghosting. The first image of the moving subject part is subjected instead to the matching of picture quality adjustment items such as brightness, edging and noise reduction before being again synthesized with the non-moving part of the subject. This process allows the non-moving part of the subject to maintain low noise thanks to superimposition and the moving part of subject to reduce blur without having the image disturbed by ghosting.

Photo 2 and **Photo 3** show examples of pictures with and without subject shake correction. See the motorbike and pedestrian on the left sides of the pictures. Photo 2 without subject

shake correction shows the motorbike and pedestrian as superimposed ghosting but Photo 3 with subject blur correction does not show superimposed ghosting.

3. PictMagic IV (Scene Categorization Type Picture Quality Improvement Function)

The PictMagic function inputs the image captured by the camera, extracts correction parameters from it by means of histogram analysis, etc., and automatically optimizes the brightness (exposure), white balance, contrast, hue, sharpness, and desirable color reproduction (Memory color correction: Skin color, blue of sky, green of trees). Its processing flow is shown in **Fig. 6** .

With the N905i, the PictMagic function has been enhanced by adding the scene categorization type picture quality improvement function, which categorizes each image automatically and applies the picture quality adjustment parameters dynamically to provide optimum correction (picture creation) to the image (**Fig. 7**).

This technology uses the scene categorization and face detection engines, both of which were developed by the NEC Common Platform Software Research Laboratories. It categorizes each image automatically by calculating its fidelity (attribute ratio) to the four scene categories of portrait or human face, night view, flower (close-up) and landscape. It then dynamically synthesizes the optimum picture quality correction parameters for each scene (**Fig. 8**).

The PictMagic function stores the picture quality correction parameters optimized for portrait, night view, flower and landscape. If the results of image analysis using the scene categorization and face detection engines show that the fidelity to the portrait, flower, night view and landscape scene categories are respectively 0.8, 0.2, 0.1 and 0.1 as shown in the example in Fig. 8, PictMagic synthesizes the correction parameters of the scene categories according to the ratio between the reliability values above and applies them to the image. In the example in Fig. 8, fidelity to the portrait scene is higher than that to other scenes, so the parameters are synthesized most optimally for the human face portrait.

Automatic calculation of correction parameters according to the fidelity to several scene categories and application to the input image makes optimum picture quality adjustment possible for each scene, which has been impossible with previous cameras.

Finally, **Fig. 9** shows the change in the processing time of PictMagic. Although the processing time basically increases following the numbers of pixels and the incorporated functions, the speed has been improved by optimizing the SW

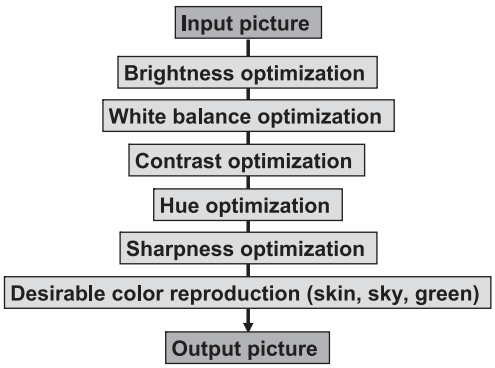

Fig. 6 Flow of PictMagic processing.

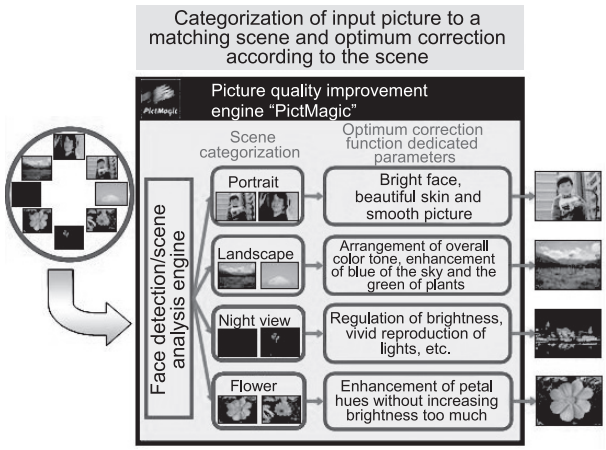

Fig. 7 Concept of scene categorization type picture quality improvement technology.

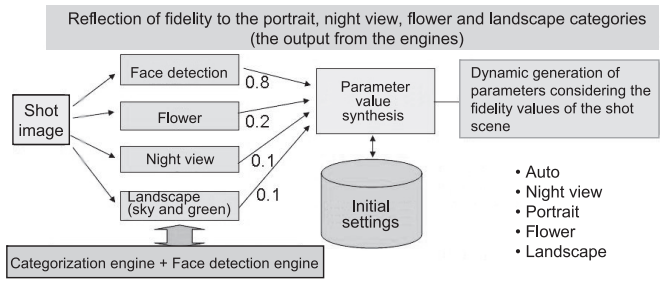

Fig. 8 Generation of picture quality correction parameters.

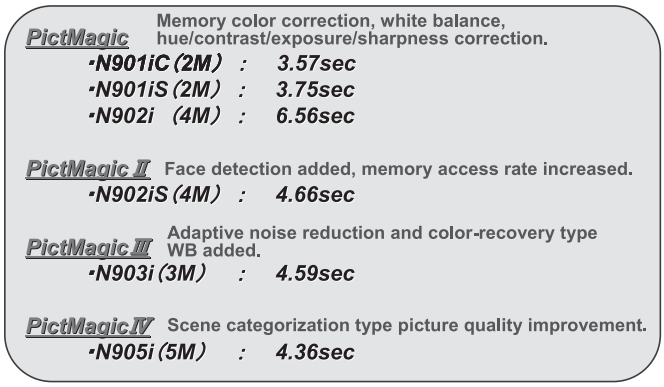

Fig. 9 Processing time of PictMagic.

program and memory access method and by improving the ACPU performance. Now, the processing of a 5M size image is possible around 4 seconds, which is an almost equivalent time period to the previous processing of a 2M size image.

4. Conclusion

Enhancements in mobile phone functions have recently been tending to increase the desirability of mounting a camera function, which has become one of the key improvements currently being introduced for the mobile phone. Camera performance and specifications are becoming key factors year on year in determining customer appeal and affecting the numbers of sold terminals. For the recently released N905i and in order to bring about significant improvements in function and performance compared to previous models we have mounted the 5M-CMOS camera, AF (autofocusing) with face detection, image stabilization with subject blur correction and PictMagic IV. We are determined thus to advance picture quality and to continue to enhance functions in order to meet the anticipated future expectations of users.

*FOMA is a registered trademark of NTT DoCoMo Corporation.

*PhotoSolid is a trademark of Morpho, Inc.

*ARM is a trademark of ARM Limited.

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