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## *Results and Discussion*

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## **4. RESULTS AND DISCUSSION**











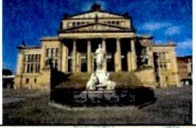
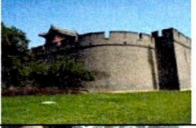

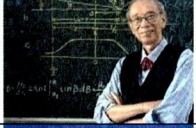
























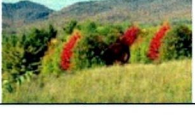

Performance evaluation is an important step that is used to analyze the efficiency of algorithms in producing the expected output. The present study is focused on developing an efficient tamper detection system using classifiers. This chapter discusses the results obtained during the performance analysis of the proposed system.

### **4.1. EXPERIMENTAL SETUP**

The CASIA TIDE v1.0 (Tampered Image Detection Evaluation Database) was used during experimentation (<http://forensics.ideatest.net>). The dataset contains 800 authentic and 925 spliced color images of size 384x256 pixels with JPEG format, totally to 1725 images. The authentic images were mostly collected from the Corel image dataset and others are taken by using three different digital cameras, namely, Canon, Nikon and Sony. All tampered images in this database are made only by splicing operation. Spliced images were generated by crop-and-paste operation using Adobe Photoshop on Windows XP. Spliced images were formed by combining images taken with different cameras. Nine different splicing combinations as listed below are thus formed.

1. Canon-Canon
2. Canon-Nikon
3. Canon-Sony
4. Nikon-Nikon
5. Nikon-Canon
6. Nikon-Sony
7. Sony-Sony
8. Sony-Canon
9. Sony- Nikon

All images are in JPEG format and belong to 8 different categories, scenery, animal, architecture, character, article, plant, nature and texture. During photomontage creation using splicing, four different types of transformations (Resize, Deform, Rotate, Do Nothing) were used with four different shapes (Circle, Rectangle, Triangle and Arbitrary). Some examples of photomontage images are shown in Figure 4.1. For simplicity, it is assumed that only two part splicing is done.

Scenery				
Animal				
Architecture				
Character				
Article				
Plant				
Nature				
Texture				
Spliced				
Spliced				

**Figure 4.1 : Example Images from CASIA TIDE Dataset**

To performance of the proposed system was evaluated using the accuracy performance metric. The accuracy is calculated using Equation (4.1).

$$\text{Accuracy} = \frac{\text{Number of correctly identified images}}{\text{Total number of images}} \times 100 \quad (4.1)$$

Apart from this the speed of the tamper detection is also used and defined as the time taken by the classifiers to classify an input image as tampered or genuine. It is calculated in Seconds.

## **4.2. EXPERIMENTAL RESULTS**

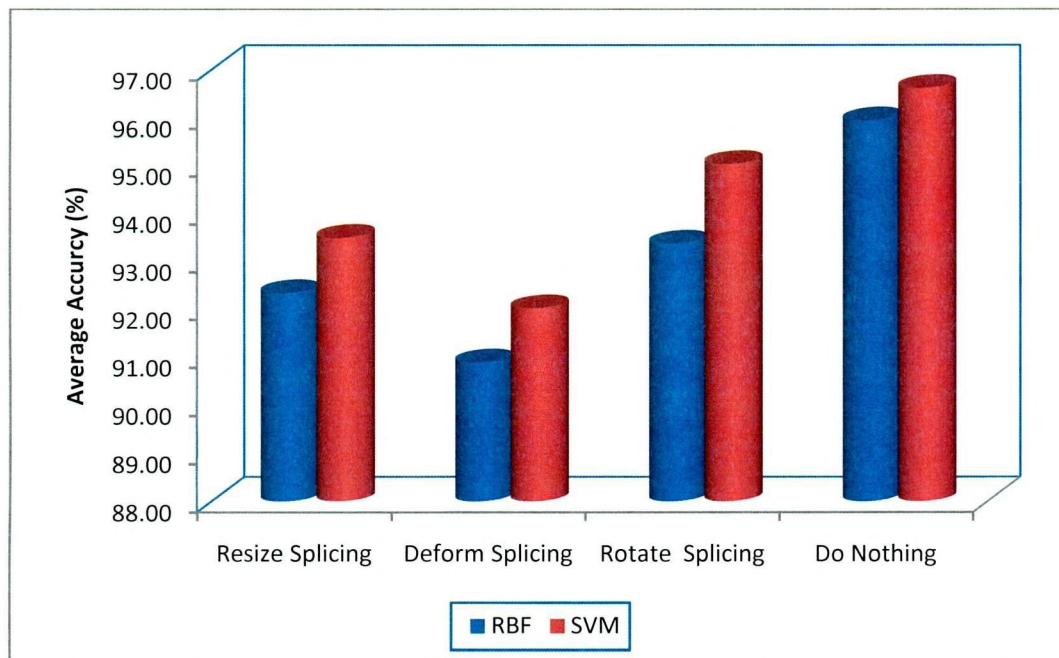
The results of the two classification based tamper detection algorithms for the three selected cameras is presented in this section. The discussion starts with the accuracy obtained by the two classifiers for the four different types of transformations (Resize, Deform, Rotate, Do Nothing), four different shapes (Circle, Rectangle, Triangle and Arbitrary) and nine different splicing combinations for tampered detection images. The efficiency of the algorithms when presented with authentic images is also analyzed for the eight different categories of images (scenery, animal, architecture, character, article, plant, nature and texture). Finally the overall performance of the systems is determined and discussed. In all the tables, C, R, T and A denotes circle, rectangle, triangle and arbitrary shape splicing.

### **4.2.1. Tampered Images**

Tables 4.1 to 4.9 present the accuracy obtained while the spliced images were created using the different combination of cameras for the various transformations and shapes. Figures 4.2 to 4.10 present the average accuracy performance of each camera combination for each type of transformations. Figure 4.11 presents overall average accuracy of the tamper detection algorithms while using SVM and RBF.

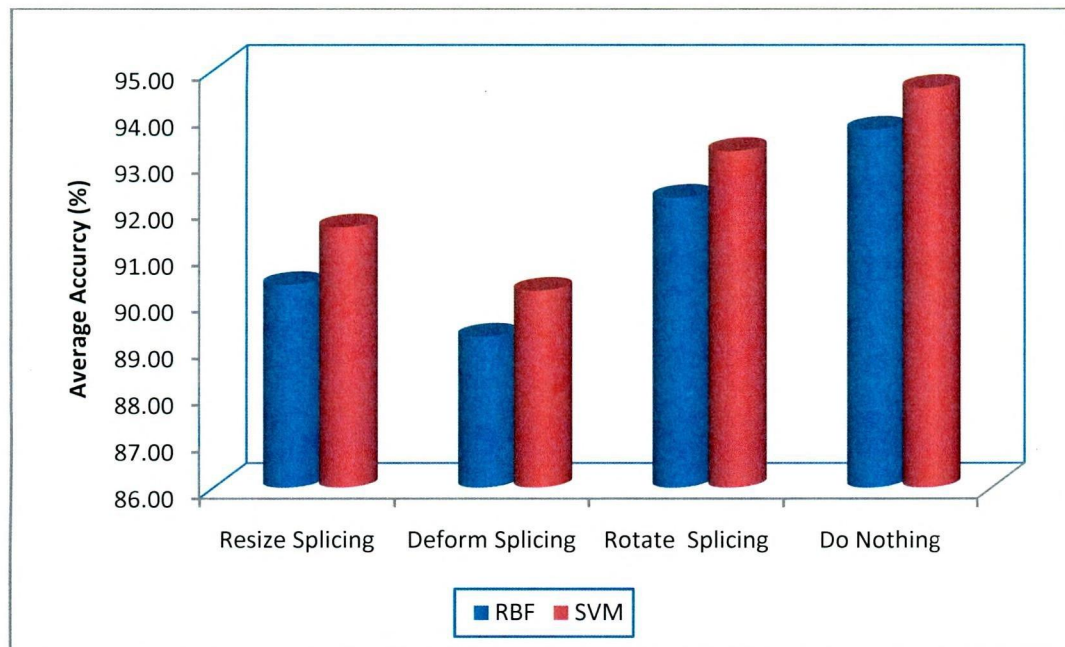
**TABLE 4.1****SONY-SONY CAMERA COMBINATION (TAMPERED IMAGES)**

Transformation	Shape	RBF	SVM
Resize Splicing	Circle	91.61	93.19
	Rectangle	93.31	95.07
	Triangle	93.00	93.63
	Arbitrary	91.43	92.07
Deform Splicing	Circle	91.15	91.48
	Rectangle	92.19	93.34
	Triangle	91.17	92.32
	Arbitrary	89.03	90.93
Rotate Splicing	Circle	93.31	94.85
	Rectangle	94.81	96.47
	Triangle	93.33	94.99
	Arbitrary	92.03	93.84
Do Nothing	Circle	95.43	96.45
	Rectangle	97.22	97.55
	Triangle	96.50	96.64
	Arbitrary	94.63	95.82

**Figure 4.2 : Average Accuracy Performance of Sony-Sony Splice Combination**

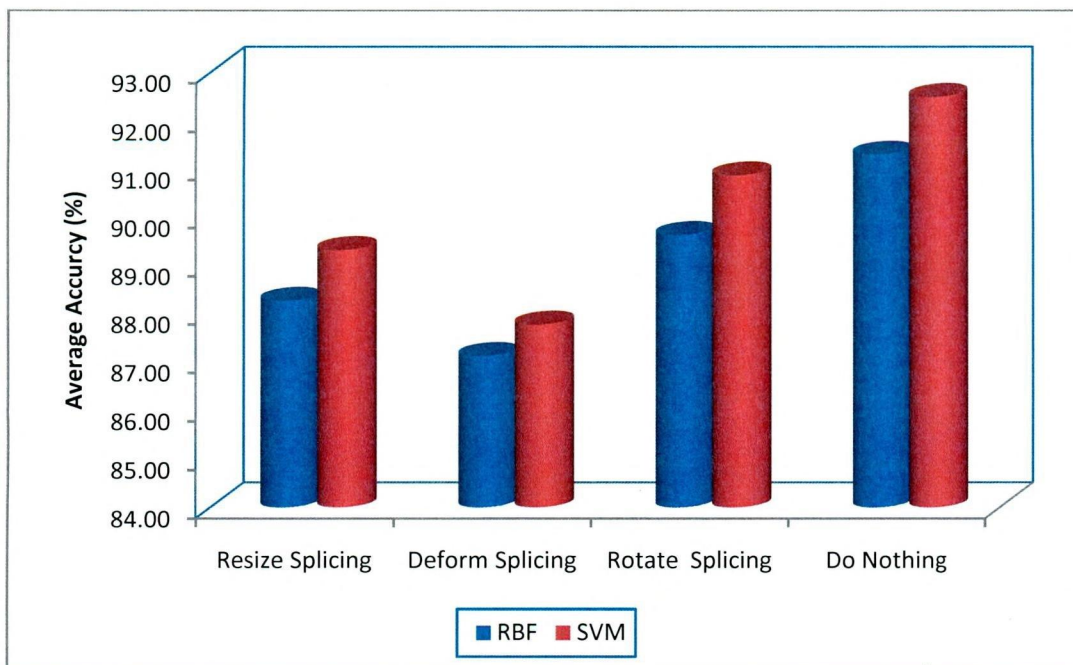
**TABLE 4.2****CANON-CANON CAMERA COMBINATION (TAMPERED IMAGES)**

<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	90.03	91.11
	Rectangle	89.68	91.67
	Triangle	90.63	92.00
	Arbitrary	91.08	91.63
Deform Splicing	Circle	88.49	90.08
	Rectangle	89.85	90.15
	Triangle	90.02	90.12
	Arbitrary	88.60	90.56
Rotate Splicing	Circle	90.81	92.79
	Rectangle	93.26	93.34
	Triangle	92.15	93.62
	Arbitrary	92.74	93.23
Do Nothing	Circle	93.53	94.31
	Rectangle	94.38	94.66
	Triangle	93.06	94.72
	Arbitrary	93.86	94.71

**Figure 4.3 : Average Accuracy Performance of Canon-Canon Splice Combination**

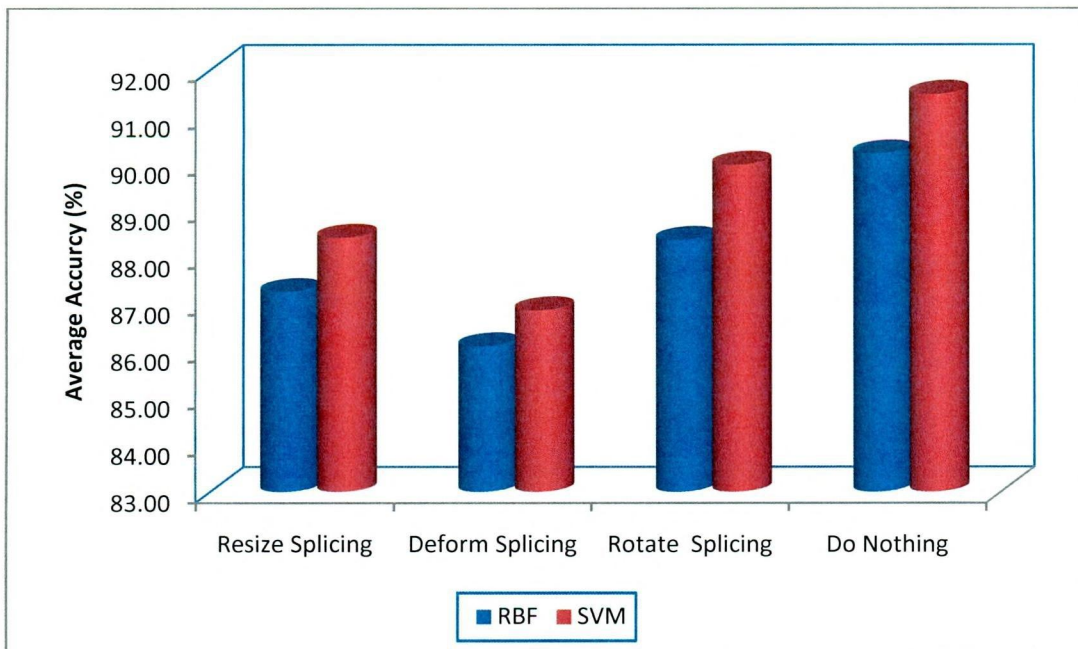
**TABLE 4.3****NIKON-NIKON CAMERA COMBINATION (TAMPERED IMAGES)**

<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	88.99	89.74
	Rectangle	87.93	89.19
	Triangle	87.27	89.02
	Arbitrary	88.87	89.32
Deform Splicing	Circle	87.29	88.25
	Rectangle	86.20	87.61
	Triangle	87.18	87.38
	Arbitrary	87.80	87.83
Rotate Splicing	Circle	89.71	90.94
	Rectangle	90.57	90.97
	Triangle	88.63	90.34
	Arbitrary	89.61	91.23
Do Nothing	Circle	90.84	92.80
	Rectangle	91.88	92.04
	Triangle	90.57	92.19
	Arbitrary	91.90	92.92

**Figure 4.4 : Average Accuracy Performance of Nikon-Nikon Splice Combination**

**TABLE 4.4**  
**NIKON SONY CAMERA COMBINATION (TAMPERED IMAGES)**

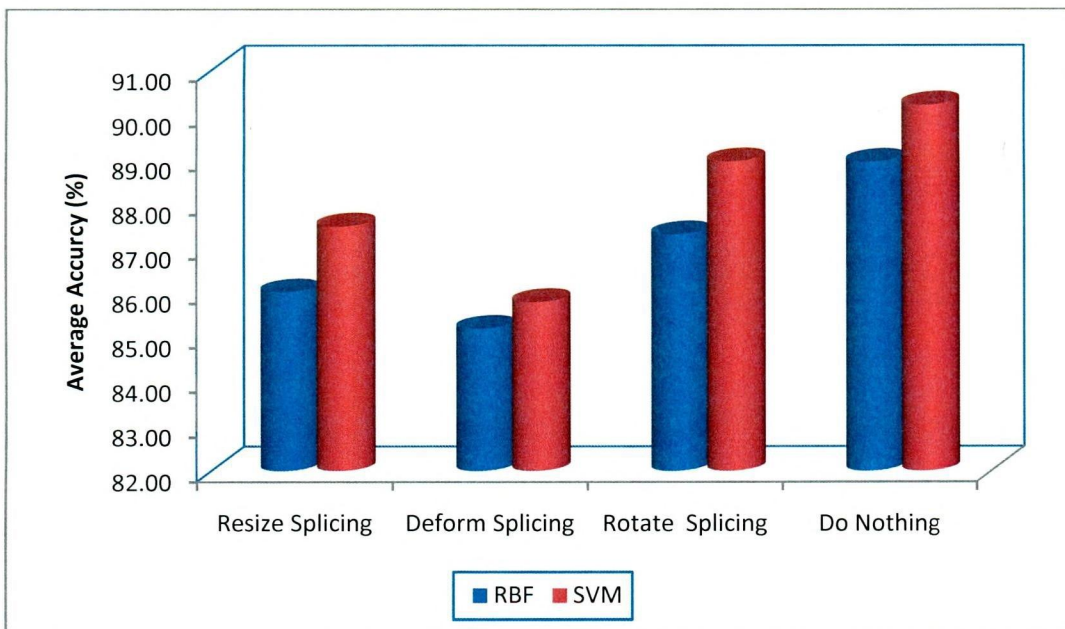
<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	87.89	88.87
	Rectangle	86.65	88.10
	Triangle	86.34	88.08
	Arbitrary	88.15	88.64
Deform Splicing	Circle	86.38	87.30
	Rectangle	84.93	86.31
	Triangle	86.17	86.17
	Arbitrary	86.91	87.69
Rotate Splicing	Circle	88.03	90.03
	Rectangle	89.36	90.16
	Triangle	87.47	89.47
	Arbitrary	88.62	90.27
Do Nothing	Circle	89.61	91.80
	Rectangle	91.48	90.40
	Triangle	89.39	91.14
	Arbitrary	90.40	92.61



**Figure 4.5 : Average Accuracy Performance of Nikon-Sony Splice Combination**

**TABLE 4.5**  
**CANON-SONY CAMERA COMBINATION (TAMPERED IMAGES)**

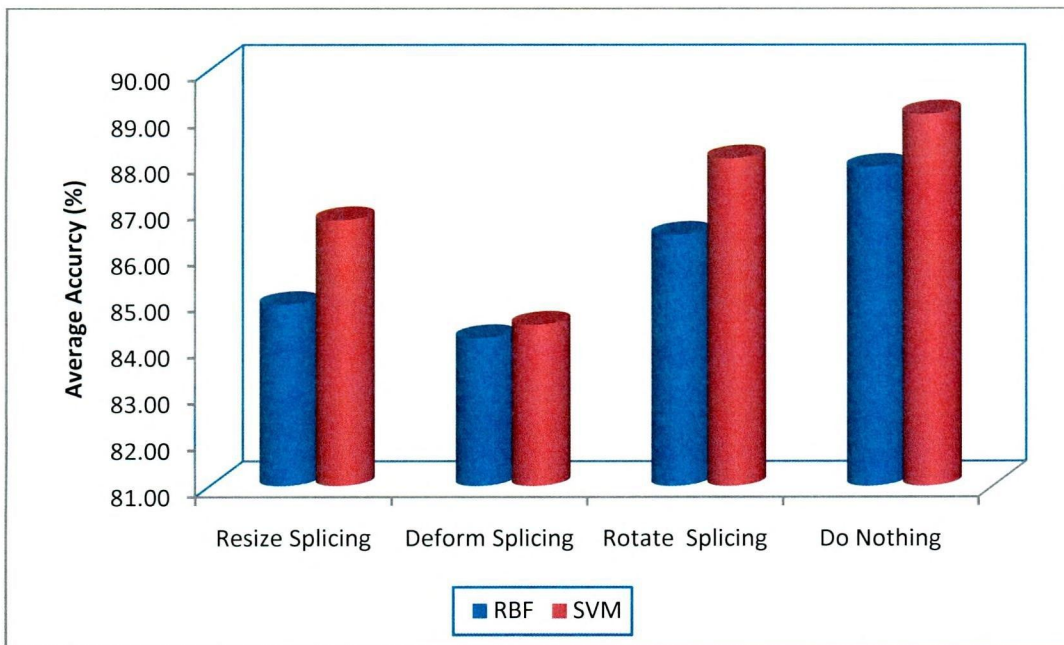
<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	86.88	87.92
	Rectangle	85.90	87.45
	Triangle	84.92	86.99
	Arbitrary	86.36	87.64
Deform Splicing	Circle	85.53	86.49
	Rectangle	84.15	85.07
	Triangle	84.37	84.99
	Arbitrary	86.72	86.61
Rotate Splicing	Circle	86.91	88.96
	Rectangle	87.89	89.78
	Triangle	87.02	87.86
	Arbitrary	87.45	89.23
Do Nothing	Circle	88.59	89.97
	Rectangle	90.12	89.18
	Triangle	88.54	90.12
	Arbitrary	88.54	91.64



**Figure 4.6 : Average Accuracy Performance of Canon-Sony Splice Combination**

**TABLE 4.6**  
**SONY-CANON CAMERA COMBINATION (TAMPERED IMAGES)**

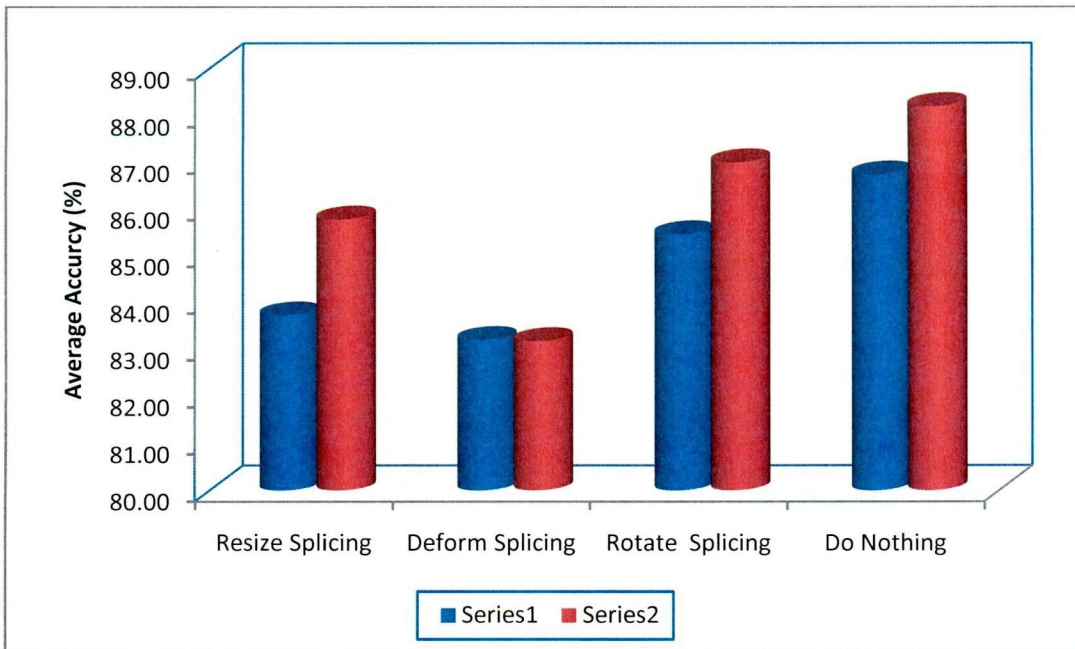
<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	85.11	87.64
	Rectangle	85.15	86.54
	Triangle	84.38	86.03
	Arbitrary	85.01	86.78
Deform Splicing	Circle	84.28	84.85
	Rectangle	83.66	83.82
	Triangle	82.88	83.74
	Arbitrary	85.94	85.50
Rotate Splicing	Circle	86.18	88.25
	Rectangle	86.98	88.68
	Triangle	85.96	86.53
	Arbitrary	86.60	88.91
Do Nothing	Circle	87.63	88.28
	Rectangle	89.30	88.36
	Triangle	87.35	88.97
	Arbitrary	87.30	90.59



**Figure 4.7 : Average Accuracy Performance of Sony-Canon Splice Combination**

**TABLE 4.7**  
**NIKON-CANON COMBINATION (TAMPERED IMAGES)**

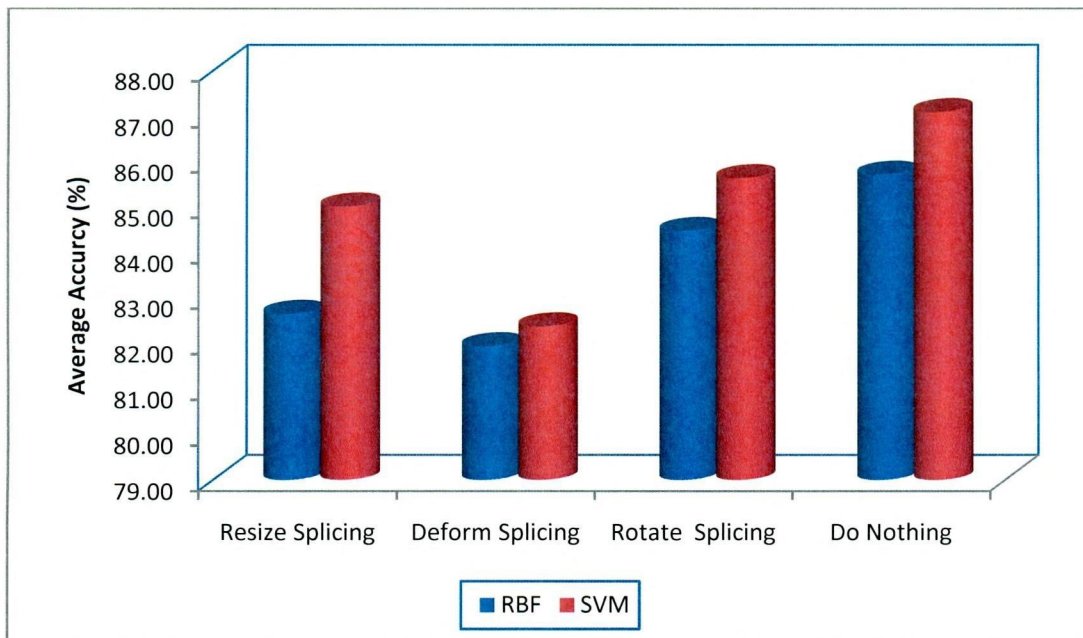
<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	84.51	86.30
	Rectangle	83.74	85.57
	Triangle	82.89	84.95
	Arbitrary	83.76	86.27
Deform Splicing	Circle	83.51	83.38
	Rectangle	82.73	83.00
	Triangle	82.21	82.40
	Arbitrary	84.35	83.92
Rotate Splicing	Circle	84.90	87.04
	Rectangle	86.81	87.61
	Triangle	84.77	85.44
	Arbitrary	85.35	87.91
Do Nothing	Circle	86.13	87.21
	Rectangle	88.48	87.57
	Triangle	86.76	88.03
	Arbitrary	85.59	89.97



**Figure 4.8 : Average Accuracy Performance of Nikon-Canon Splice Combination**

**TABLE 4.8**  
**CANON-NIKON CAMERA COMBINATION (TAMPERED IMAGES)**

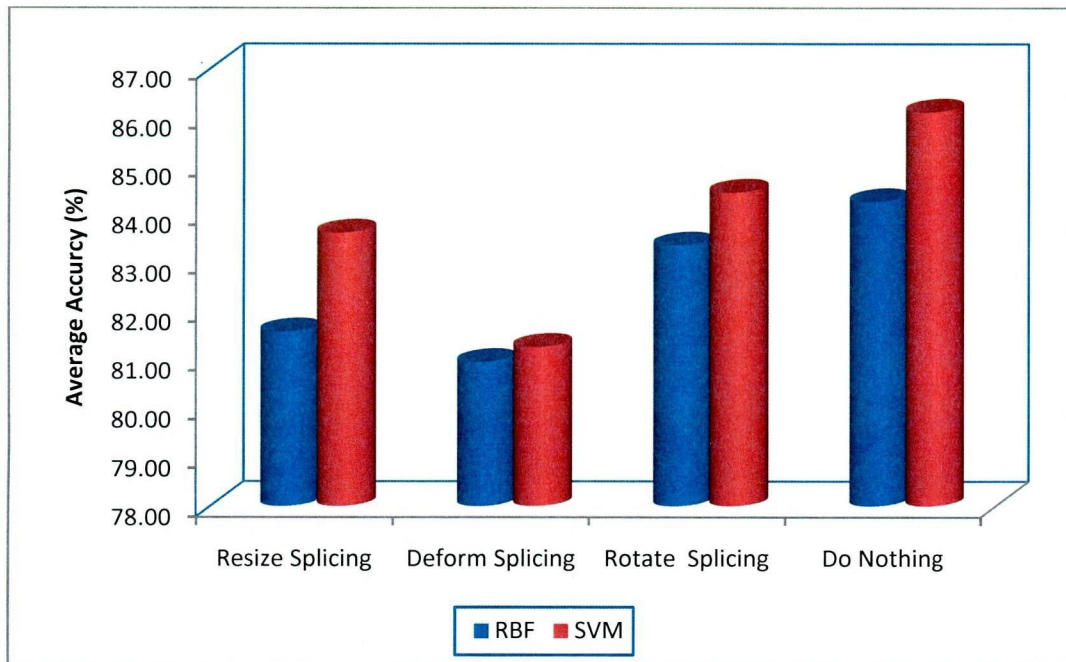
<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	83.98	85.70
	Rectangle	82.39	84.18
	Triangle	81.68	84.32
	Arbitrary	82.53	85.82
Deform Splicing	Circle	82.52	82.33
	Rectangle	81.09	82.12
	Triangle	80.99	81.99
	Arbitrary	83.12	83.02
Rotate Splicing	Circle	83.10	85.63
	Rectangle	85.98	86.09
	Triangle	84.05	84.38
	Arbitrary	84.75	86.43
Do Nothing	Circle	84.89	86.23
	Rectangle	87.48	86.73
	Triangle	85.61	86.17
	Arbitrary	84.86	89.23

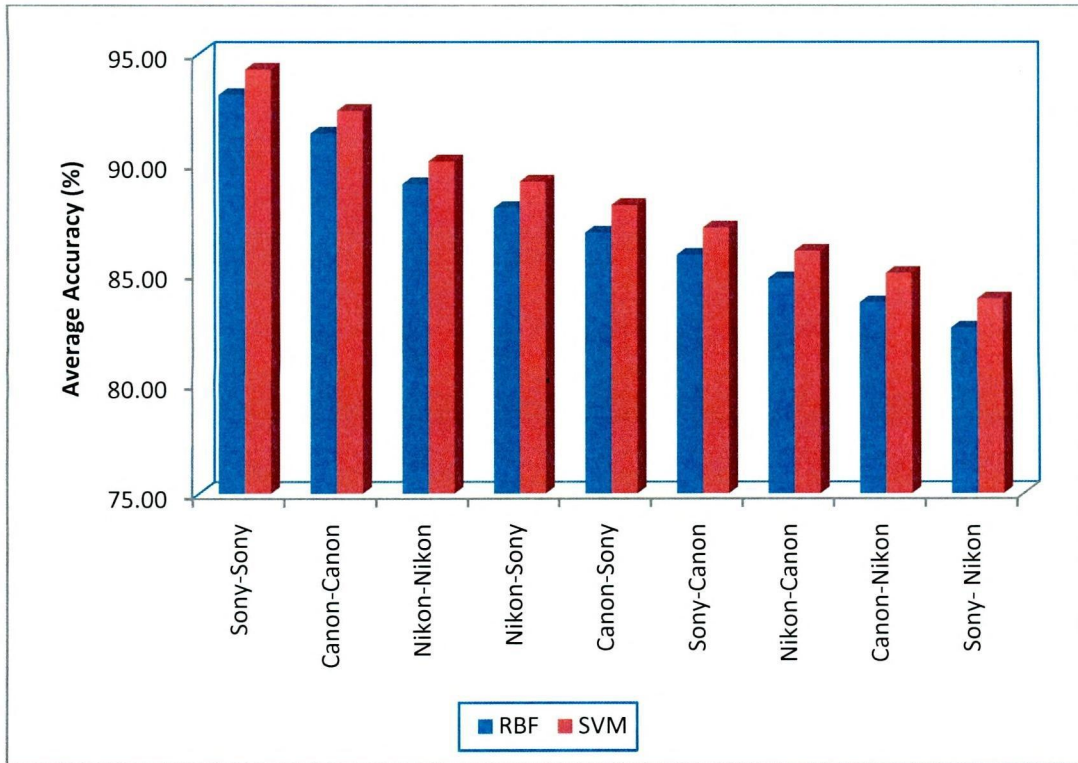


**Figure 4.9 : Average Accuracy Performance of Canon-Nikon Splice Combination**

**TABLE 4.9****SONY NIKON CAMERA COMBINATION (TAMPERED IMAGES)**

<b>Transformation</b>	<b>Shape</b>	<b>RBF</b>	<b>SVM</b>
Resize Splicing	Circle	82.56	84.25
	Rectangle	81.30	82.43
	Triangle	80.31	83.06
	Arbitrary	82.14	84.74
Deform Splicing	Circle	81.31	81.46
	Rectangle	80.17	81.65
	Triangle	80.21	80.69
	Arbitrary	82.11	81.25
Rotate Splicing	Circle	82.18	84.76
	Rectangle	84.45	85.02
	Triangle	82.43	83.00
	Arbitrary	84.38	85.02
Do Nothing	Circle	83.79	84.97
	Rectangle	85.95	85.86
	Triangle	83.80	85.57
	Arbitrary	83.50	88.02

**Figure 4.10 : Average Accuracy Performance of Sony-Nikon Splice Combination**

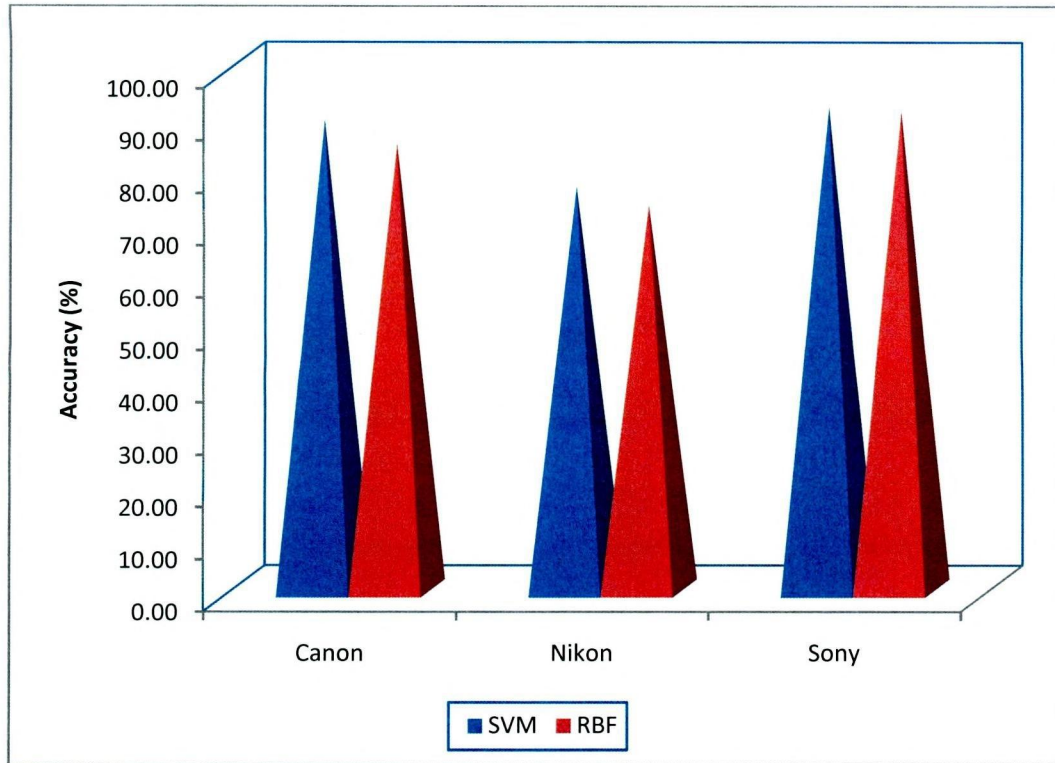


**Figure 4.11 : Average Overall Accuracy (Tampered Images)**

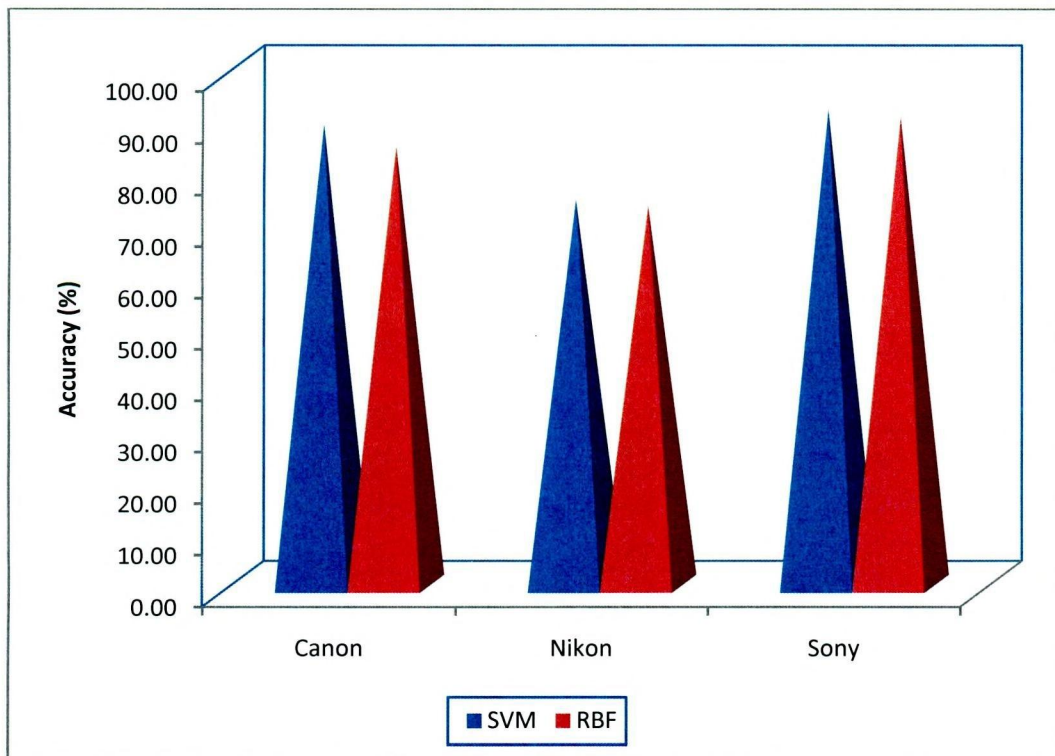
From the various results, it can be seen that maximum efficiency is produced when SVM one-class classifier is used. While considering the shape, the system is efficient in identifying tampered images formed using rectangle shape followed by triangle. Poor performance was obtained when arbitrary shape was used during splice creation. Considering transformations, best performance was achieved when no transformation was used while photomontage was created. When used, the system was able to find rotate transformation tampering followed by resizing modifications. Further, the system was efficient in identifying tampered images correctly when both the slices were taken from the same camera.

#### **4.2.2. Authentic Images**

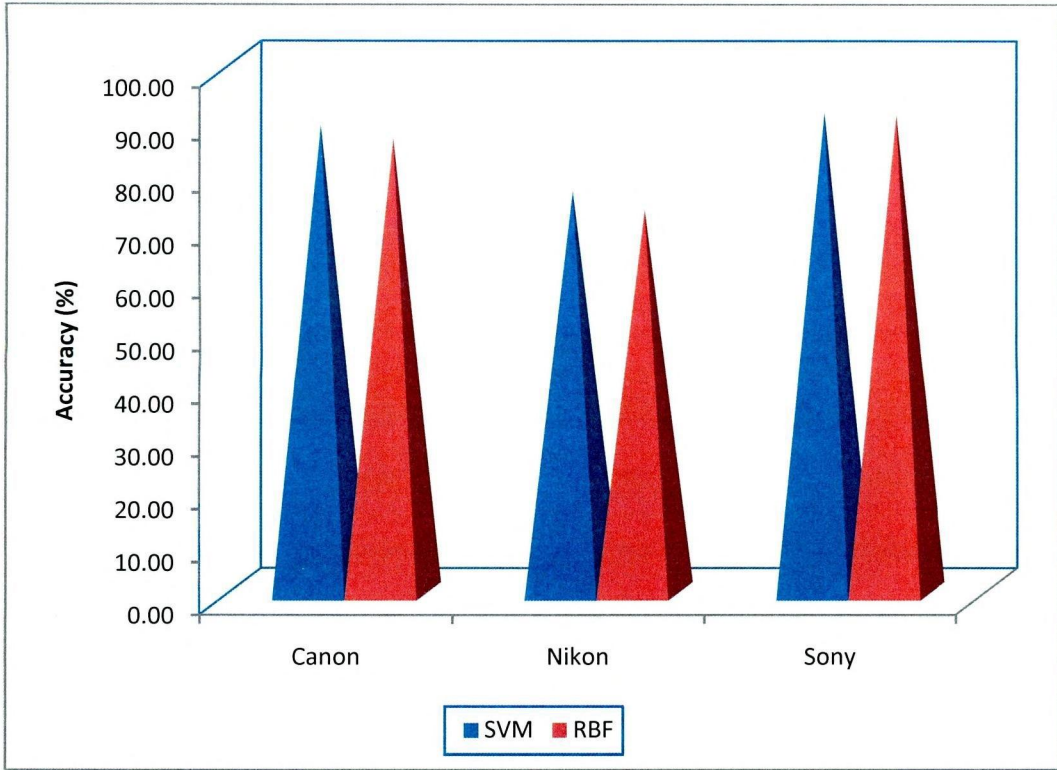
Figures 4.12 to 4.19 shows the accuracy of authentic image detection process applied to the eight different categories of images, for the three different camera images using the two one-class classifiers, SVM and RBF. The overall comparison of authentic image detection is shown in Figure 4.20.



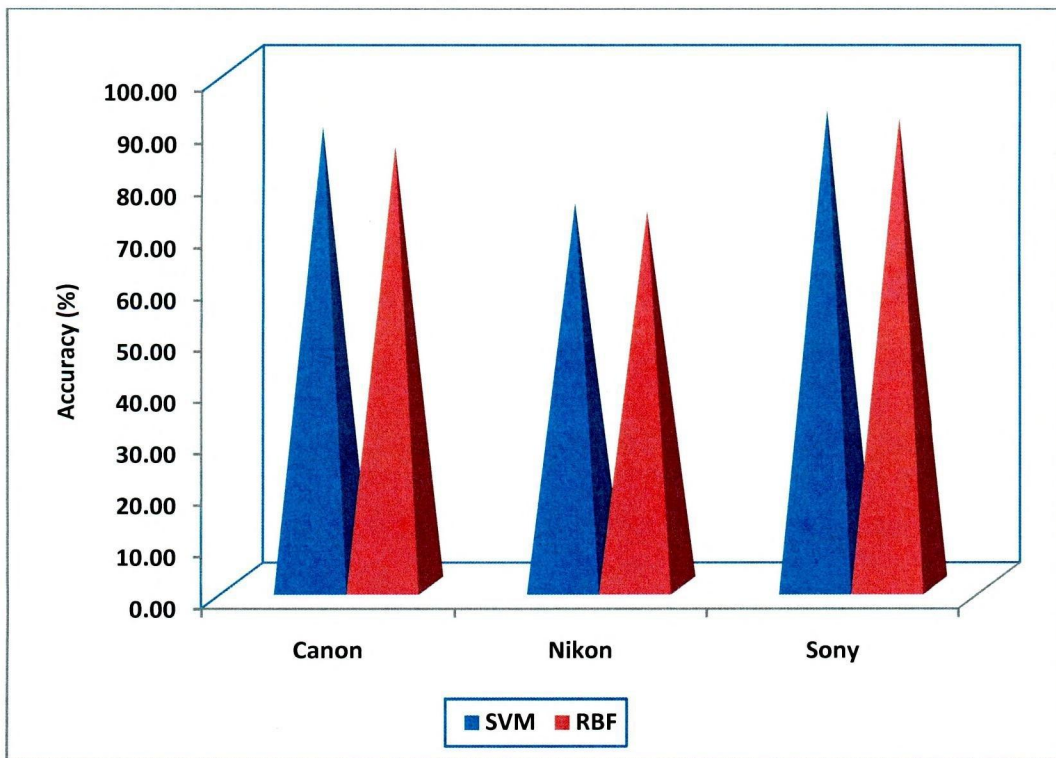
**Figure 4.12 : Accuracy of Authentic Images (Scenery)**



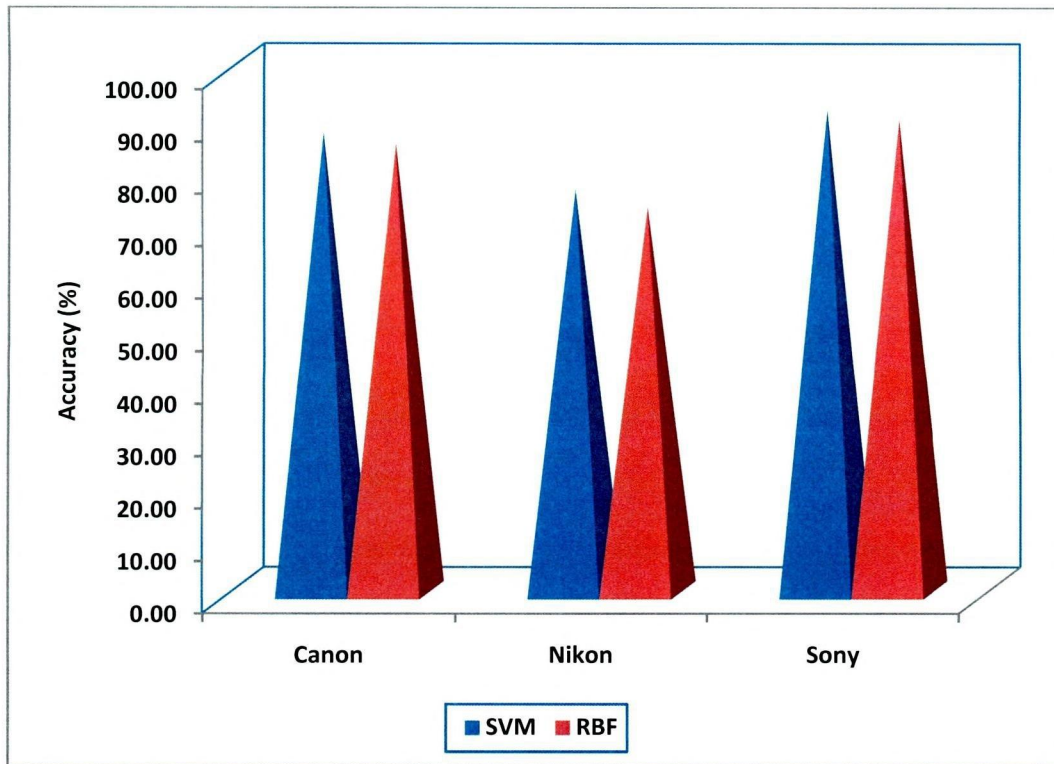
**Figure 4.13 : Accuracy of Authentic Images (Animal)**



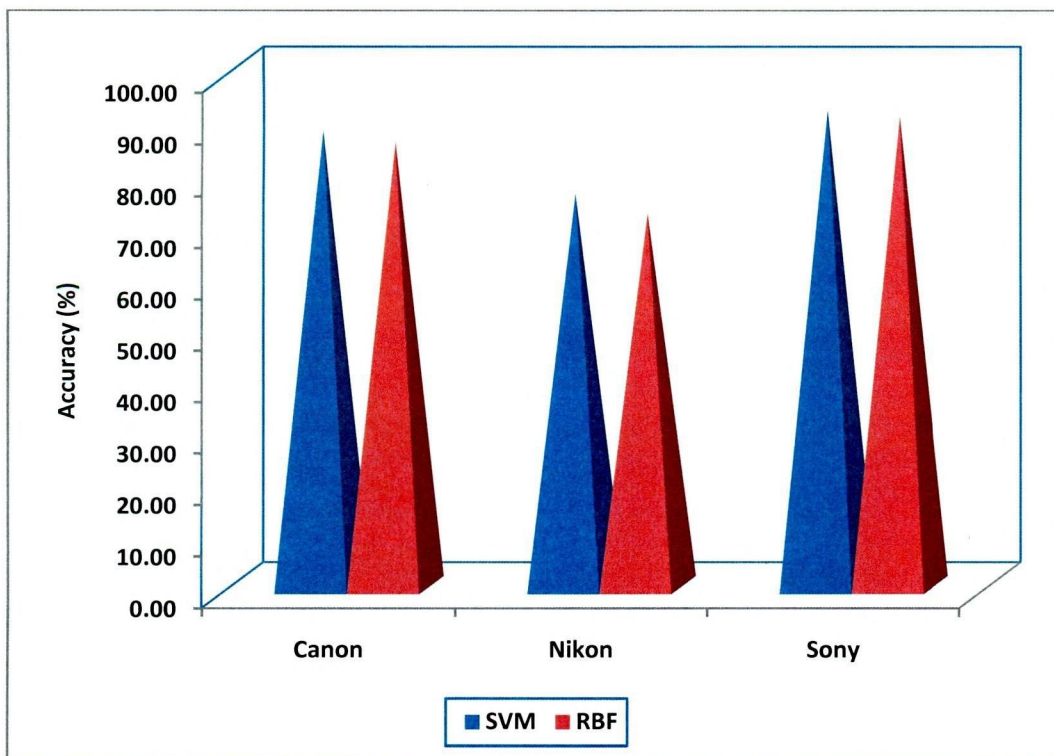
**Figure 4.14 : Accuracy of Authentic Images (Architecture)**



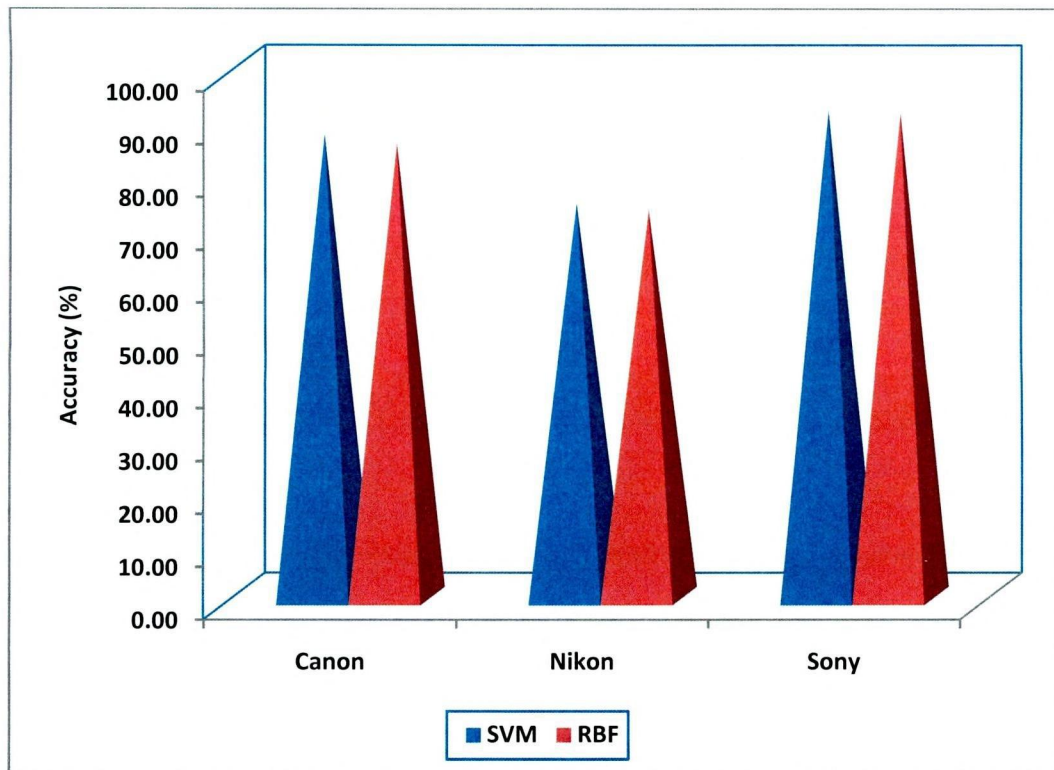
**Figure 4.15 : Accuracy of Authentic Images (Character)**



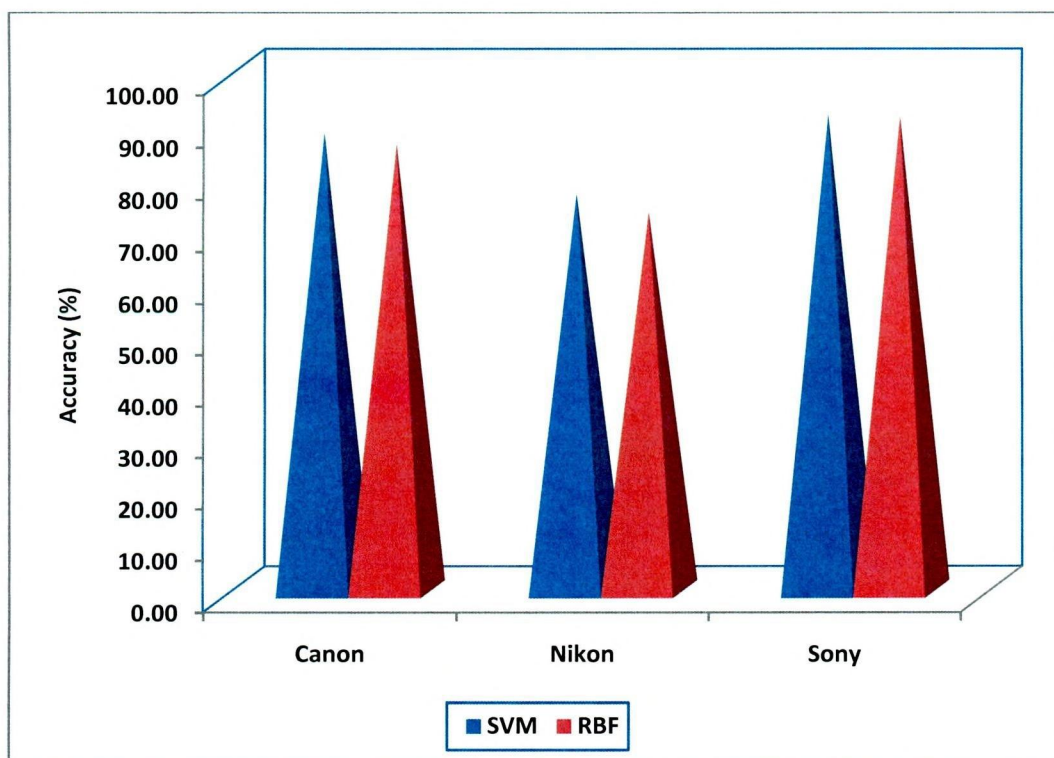
**Figure 4.16 : Accuracy of Authentic Images (Article)**



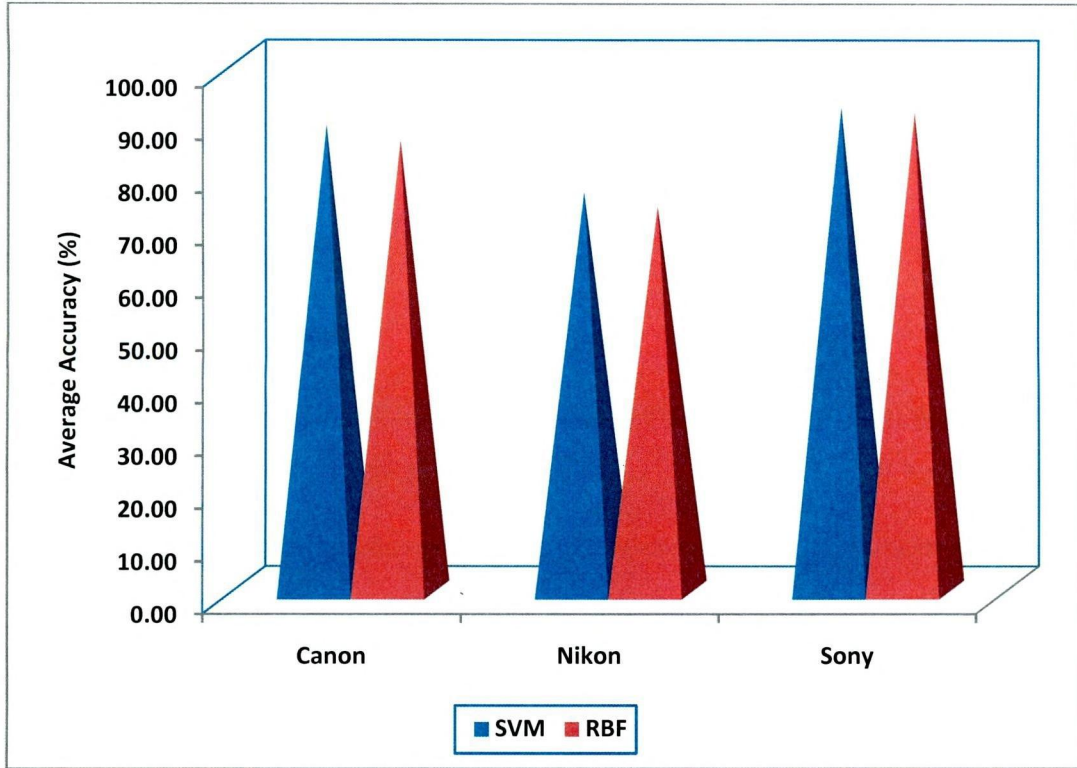
**Figure 4.17 : Accuracy of Authentic Images (Plant)**



**Figure 4.18 : Accuracy of Authentic Images (Nature)**



**Figure 4.19 : Accuracy of Authentic Images (Texture)**

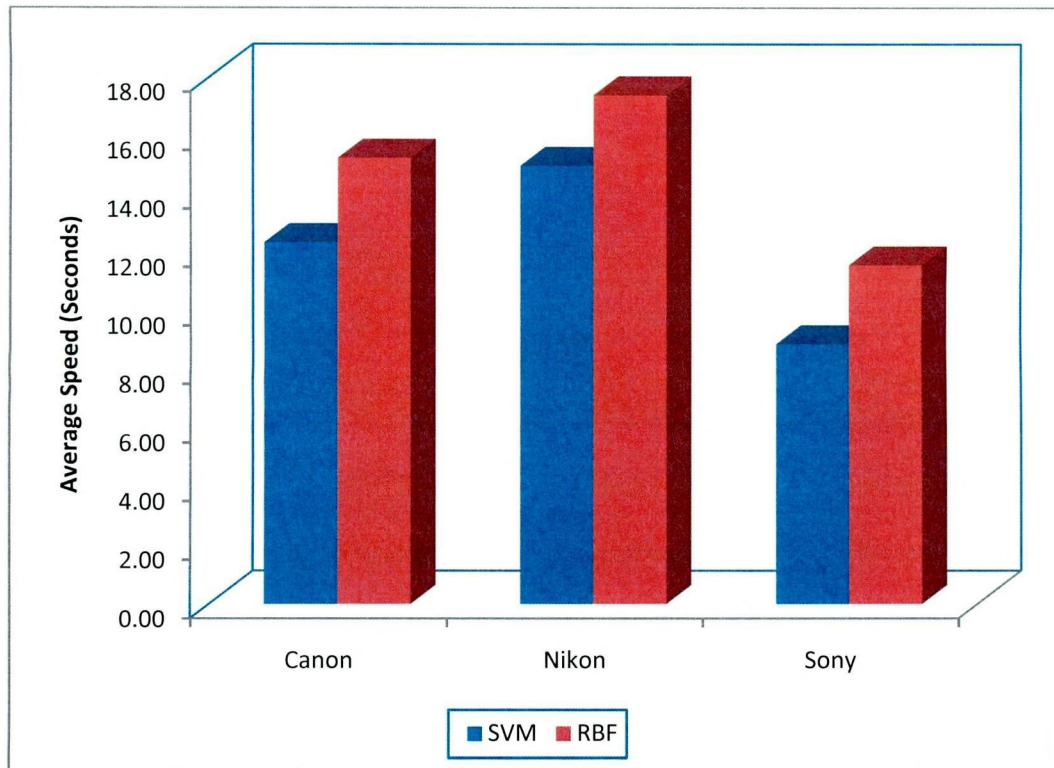


**Figure 4.20 : Overall Accuracy of Authentic Image Identification**

With all the 8 categories of images, the SVM based one-class classifier’s performance was better when compared with RBF classifier in identifying authentic images also. The algorithm worked efficiently with Sony images followed by Cannon and finally Nikon images. The SVM-based system produced an efficiency gain of 3.2%, 3.55% and 1.04% when compared with RBF-based system for Canon, Nikon and Sony cameras respectively.

### 4.2.3. Speed of Identification

Figure 4.21 shows the average speed of tamper detection algorithms based on SVM and RBF one class classifiers.



**Figure 4.21 : Average Speed**

Figure 4.21 shows that the SVM algorithm is quick in identifying tampered and genuine images when compared with RBF algorithm. The SVM algorithm on average was able to produce identification results in less than 12.07 seconds, while RBF algorithm took 14.74 seconds.

All the results show that the SVM-based tamper identification algorithm is efficiency in terms of accuracy and time complexity while using camera statistic features.

### **4.3. CONCLUSION**

The high accuracy value obtained the SVM and RBF based algorithms while using camera statistics showed that the applicability of camera specific features is a promising method for tamper detection. The work is concluded with future research directions in the next chapter.