

# **An Efficient Diamond Search with Large Kite Search Patterns for Fast Block Motion Estimation**

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# Outline

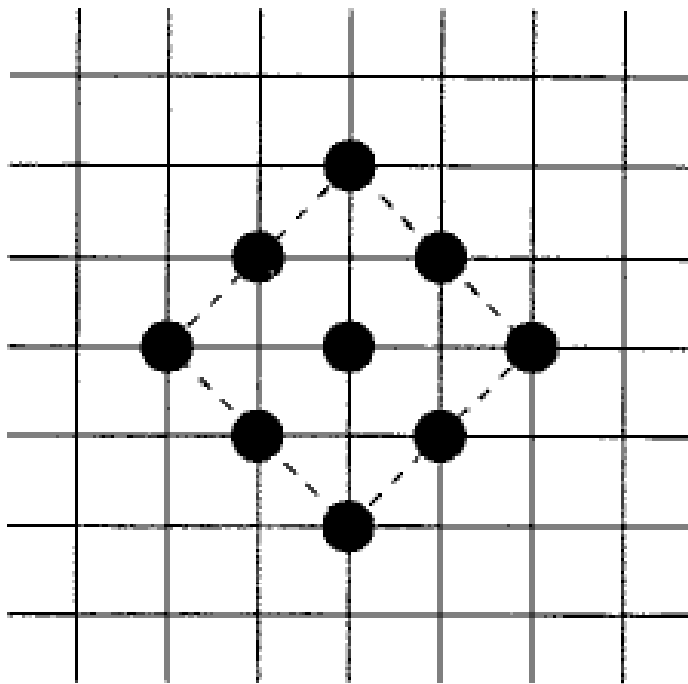
- Introduction
- Modified Large Diamond-shaped Patterns (MLDSP)
- Proposed Algorithm
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# Introduction

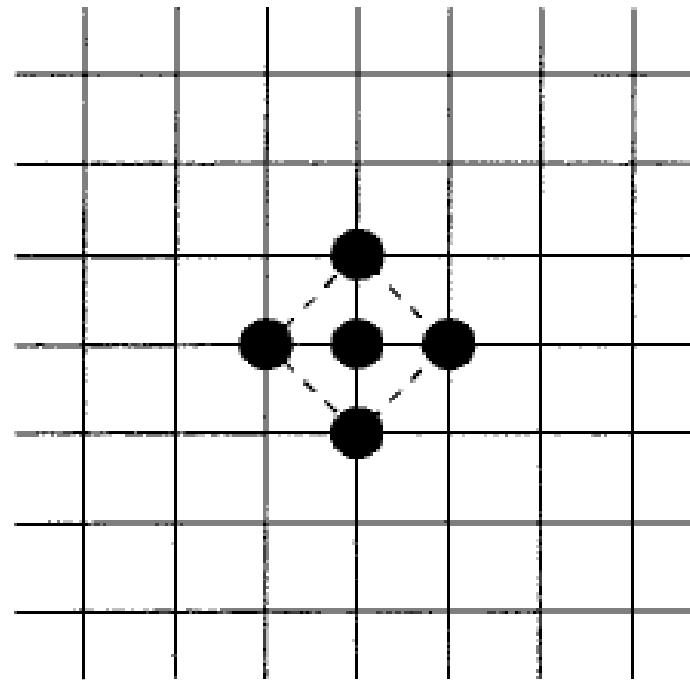
- This paper propose a novel scheme for the small target motion vector (MV)
  - It gives the fastest search for the small MV
- Simulation results show that the proposed algorithm
  - Maintains similar or even smaller distortion
  - Achieves a great speed improvement compared with other block-matching algorithm (BMA)

# Diamond Search

- The DS algorithm employs two search patterns as illustrated in Fig. 1



(a) Large diamond search pattern (LDSP)



(b) Small diamond search pattern (SDSP)

Fig. 1 Two search patterns

# MLDSP for motion direction

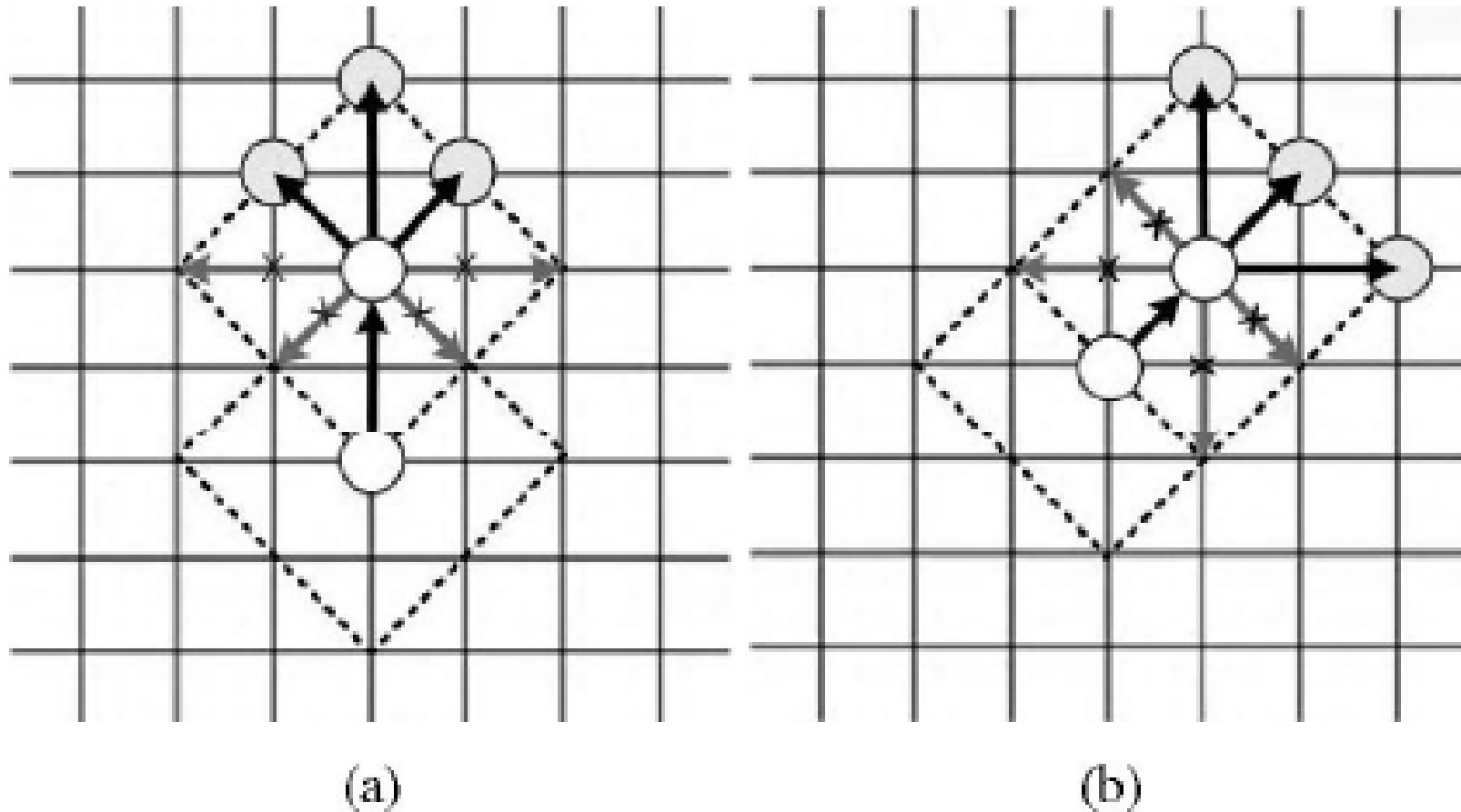


Fig. 2 (a) MLDSP for the vertical motion direction  
(b) MLDSP for the diagonal motion direction

# Proposed Algorithm

- The proposed algorithm is organized into the four phases
  - Initial search for small MV
  - Determination of the size of the target MV
  - Coarse search with MLDSP
  - Fine search with MLDSP

# Ph.1 - Initial search for small MV (1/2)

- The SDSP is located at the center of the search window
- If the minimum block distortion measure (BDM) occurs at the center point of the SDSP
  - The search stops
- Otherwise
  - A new SDSP is formed by repositioning the previous minimum BDM point as the center of the SDSP

# Ph.1 - Initial search for small MV (2/2)

- If the center point of the newly formed SDSP has the minimum BDM
  - The search terminates
- Otherwise
  - The search goes to the next phase



# Examples for the Initial search

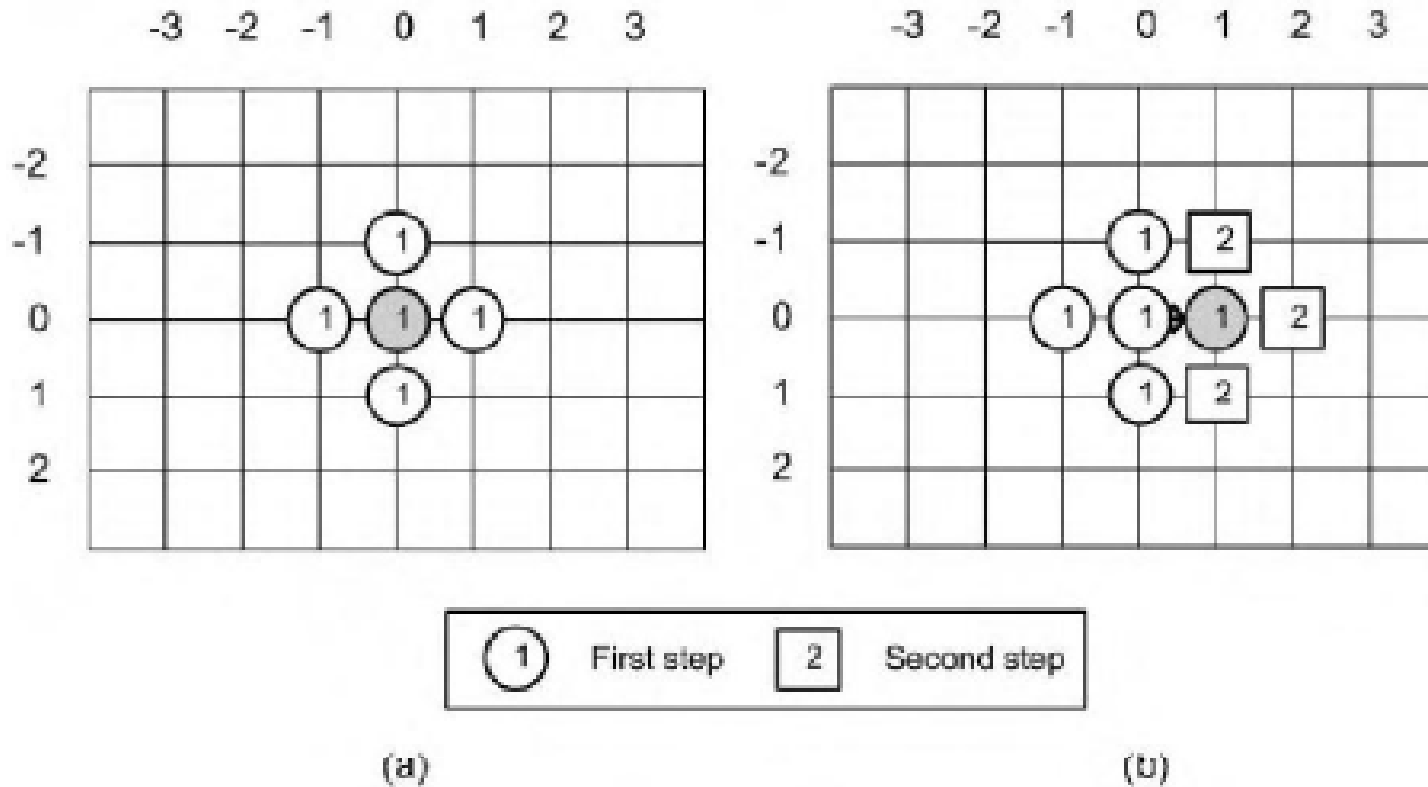


Fig. 3 (a) The target MV (0,0)  
(b) The target MV (+1,0)

# Large Kite Search Patterns

- From the initial phase, we can select one direction that the probability of the target MV found is higher than the other three directions
- Regarding this, we found the search pattern that fits the purpose well which is the large kite-shaped pattern (LKSP)
  - It has four different types as shown in Fig. 4

# Large Kite Search Patterns

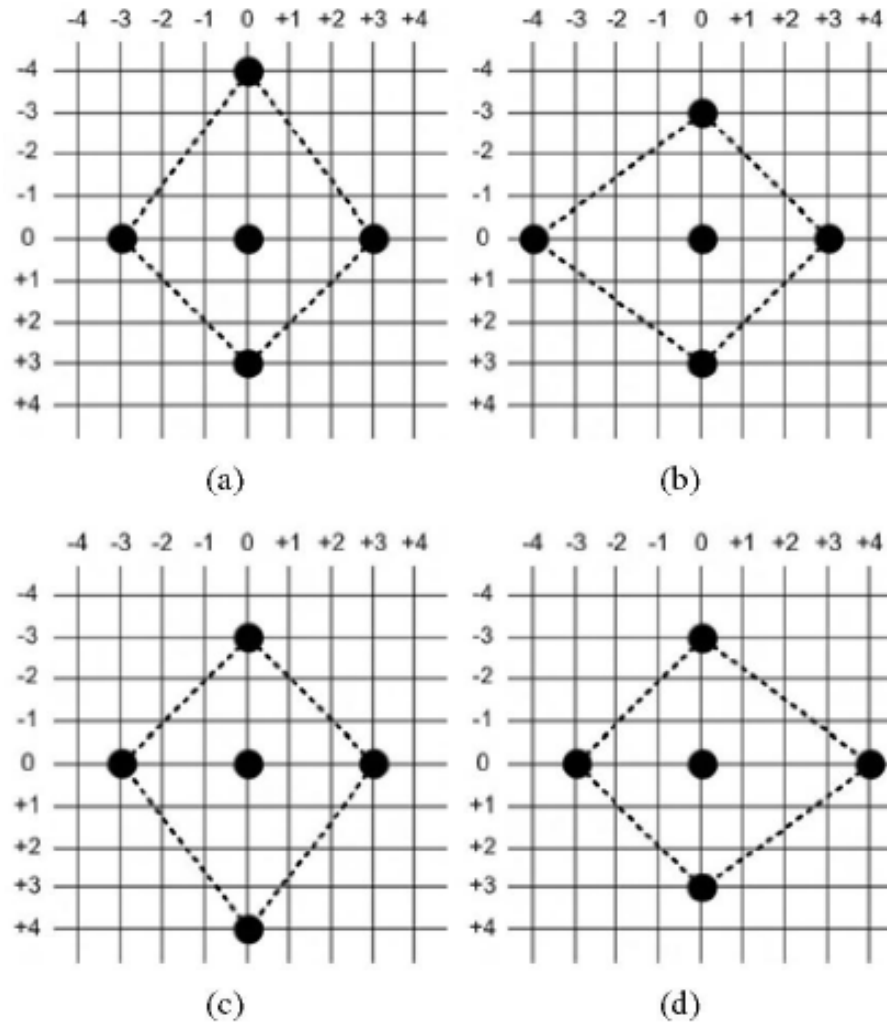


Fig. 4 (a) large up-kite, (b) large left-kite,  
(c) large down-kite, (d) large right-kite

## **Ph.2 - Determination of the size of the target MV (1/2)**

- If the minimum BDM point is located in upper vertex of the first SDSF
  - The LKSP will have a large up-kite shape
- In this phase, four points on the LKSP are evaluated and compared with the minimum BDM in the first phase

# Ph.2 - Determination of the size of the target

## MV (2/2)

- If the minimum BDM point is on LKSP
  - The search proceeds to the coarse search phase
  
- Otherwise
  - The search goes to the fine search phase

## Ph.3 - Coarse search with MLDSP (1/2)

- In this phase, the MLDSP leads a new search center to the most promising area which is around the global minimum
- Considering the dominant direction of the LKSP
  - MLDSP is located at the minimum BDM point from the previous phase

## Ph.3 - Coarse search with MLDSP (2/2)

- If the new minimum BDM point is at the center of the newly formed MLDSP
  - The search goes to the fine search phase
  
- Otherwise
  - The MLDSP is repeatedly formed regarding the minimum BDM point as the new center of the MLDSP until the minimum BDM point is still at the center point of the newly formed MLDSP
  - Then the search proceeds to the fine search phase

## Ph.4 - Fine search with SDSP

- Unlike conventional search algorithms, the proposed algorithm can use the small size search pattern repeatedly for the final refinement search
  - This unrestricted refinement search needs more checking points
  - But it guarantees a higher accuracy of BMA



# Examples for the Proposed Algorithm

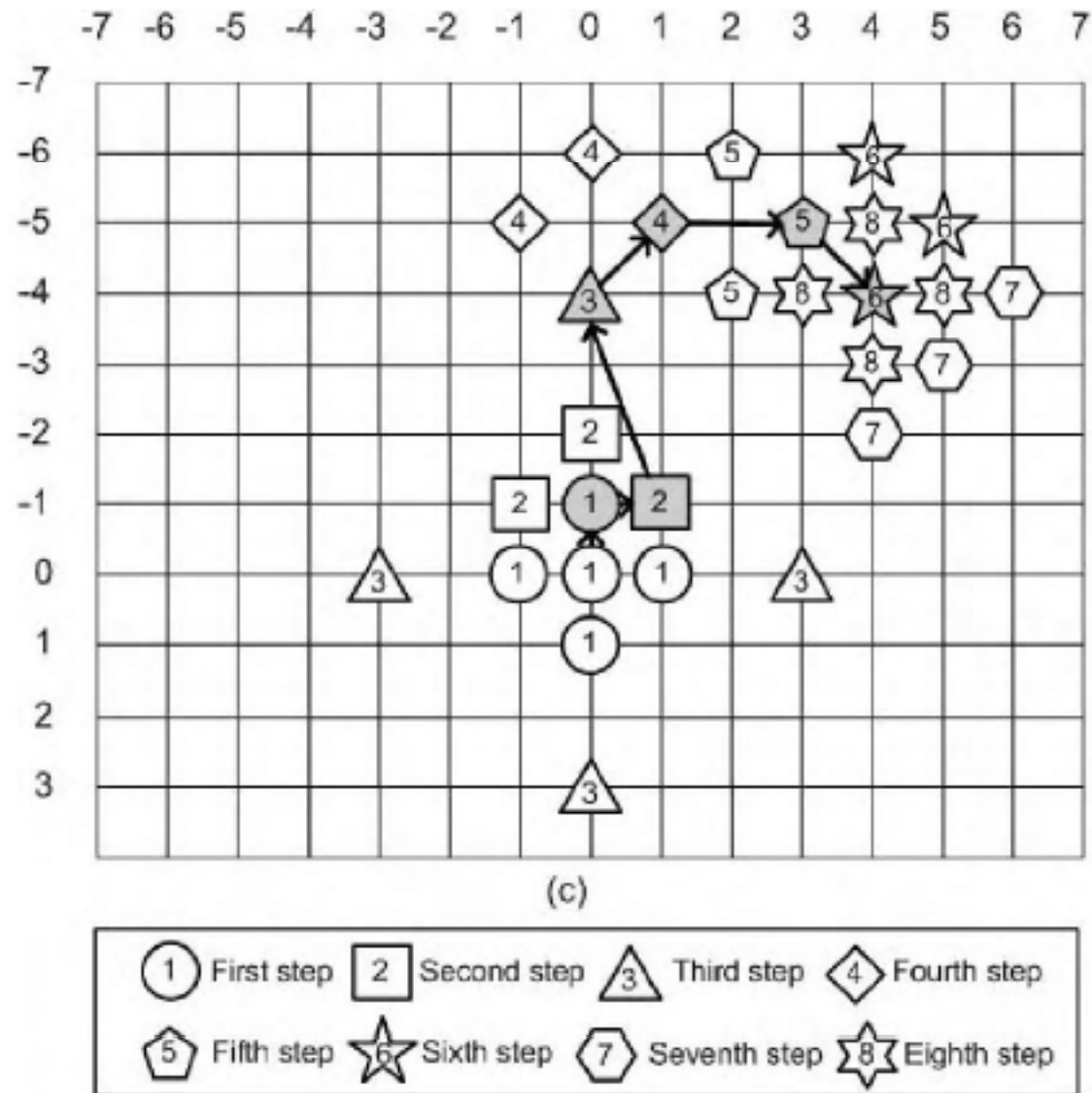


Fig. 5 The target MV (+4,-4)

# Experimental Results

Table 1 Average number of searching points per block

<i>Format</i>	<i>Sequence</i>	FS	TSS	DS	CDS	CDHS-F	KCDS	<b>Proposed</b>
QCIF	Mother&Daughter	225	25	13.396	9.601	6.025	5.8	<b>5.631</b>
	Carphone	225	25	14.933	11.92	9.365	8.782	<b>8.116</b>
	Foreman	225	25	16.429	13.764	11.161	10.903	<b>9.863</b>
	Suzie	225	25	14.299	10.969	8.154	7.692	<b>7.229</b>
SIF	Football	225	25	17.377	15.551	12.68	12.715	<b>11.436</b>
	Garden	225	25	17.664	15.349	14.185	13.066	<b>11.827</b>
	Foreman	225	25	19.539	18.186	15.227	15.745	<b>13.628</b>
	Mobile	225	25	13.835	10.803	10.229	8.522	<b>7.655</b>
CIF	Coastguard	225	25	17.668	16.868	15.015	14.159	<b>13.114</b>
	Container	225	25	13.124	9.176	5.232	5.19	<b>5.148</b>
	Mobile	225	25	14.242	10.942	10.136	8.578	<b>7.727</b>
	Tennis	225	25	15.146	12.629	9.348	9.304	<b>8.695</b>

# Experimental Results

Table 2 Average mean absolute error per pixel

<i>Format</i>	<i>Sequence</i>	FS	TSS	DS	CDS	CDHS-F	KCDS	<b>Proposed</b>
QCIF	Mother&Daughter	1.644	1.652	1.648	1.65	1.651	1.65	<b>1.651</b>
	Carphone	3.255	3.37	3.34	3.373	3.388	3.377	<b>3.381</b>
	Foreman	3.196	3.415	3.456	3.473	3.552	3.49	<b>3.483</b>
	Suzie	2.362	2.428	2.384	2.403	2.411	2.406	<b>2.411</b>
SIF	Football	10.467	11.012	10.964	11.059	11.287	11.193	<b>11.183</b>
	Garden	7.977	9.171	8.25	8.164	8.201	8.19	<b>8.171</b>
	Foreman	3.637	3.927	3.936	3.947	4.159	3.969	<b>3.982</b>
	Mobile	9.43	9.719	9.518	9.444	9.444	9.445	<b>9.445</b>
CIF	Coastguard	4.612	4.719	4.67	4.672	4.688	4.697	<b>4.675</b>
	Container	1.683	1.684	1.686	1.686	1.687	1.686	<b>1.687</b>
	Mobile	7.805	8.062	7.856	7.844	7.845	7.845	<b>7.846</b>
	Tennis	2.935	3.278	3.054	3.084	3.144	3.16	<b>3.131</b>

# Reference

- [1] S. Zhu and K. K. Ma, "A new diamond search algorithm for fast block-matching motion estimation," *IEEE Trans. Image Processing*, vol. 9, pp. 287-290, Feb. 2000.
- [2] H. S. Lee, J. H. Jung, and D. J. Park, "An Efficient Diamond Search with Large Kite Search Patterns for Fast Block Motion Estimation," *IEEE Trans. Image Processing*, pp. 3137-3141, Oct. 2006.