Image Registration Techniques for Multi-Modality Imaging: A Survey

S. Senthamilarasu
Assistant Professor, Department of Electronics and Communication Engneering,
P A College of Engineering and Technology,
85senthamil@gmail.com

Abstract **- This paper expects to exhibit a survey of later and in addition exemplary picture enrollment strategies. Image registration is the process of overlaying images (two or more) of the same scene taken at different times, from different view angles, and by image acquisition devices. The registration techniques geometrically align two images (the reference and perceived images). The inspected methodologies are arranged by their tendency (area based and feature-based) and according to four basic steps of image registration procedure: feature detection, feature matching, mapping function design and image transformation and resampling. Main contributions, merits, and downsides of the methods are mentioned in the paper. Tricky issues of picture enrollment and viewpoint for the future research are talked about as well. The real objective of the paper is to give a far reaching reference source to the specialists engaged with picture enrollment, paying little mind to specific application.**

Key Words **- Image Registration, Multi Modality Imaging, Image Enrolement, Multi Temporal, Multi View analysis**

I. INTRODUCTION

Image registration is the way toward overlaying at least two pictures of a similar scene taken at various occasions, from various perspectives, as well as by various sensors. It aligns two images the reference and sensed images based on geometric parameters. The present contrasts between pictures are acquainted due with various imaging conditions. Picture enlistment is a significant advance in all picture investigation errands in which the last data is picked up from the blend of different information sources like image fusion, change detection, and multichannel image restoration. Typically, registration is required in remote sensing (multispectral classification, environmental monitoring, change detection, image mosaicing, weather forecasting, creating super-resolution images, integrating information in to geographic information systems (GIS)), in medicine, computer tomography (CT) and NMR data are combined to obtain more complete information about the patient, monitoring tumor growth, treatment verification, comparison of the patient's data with anatomical atlases), in cartography (map updating), imaging nano-scale particles (TEM) and in computer vision.

To register images, determination of geometric transformation is needed, that aligns images with respect to the reference image. The popular transformations are rigid, affine, projective, perspective and global transformations. Over all these years, a numerous techniques has been developed for various types of problems. Every one of these methods have been freely examined for various applications. This paper sorts out this examination by setting up the connection between the varieties in the pictures and the kind of enrollment procedures which can most suitably be connected. All registration techniques explained in the paper are useful for understanding the merits and relationships between the wide variety of existing techniques and for supporting in the selection of the most appropriate technique for a particular problem.

II. IMAGE ANALYSIS TECHNIQUES

Image registration is mostly used in remote sensing, medical imaging, computer vision, Multi modality imaging, imaging nano particles, etc. In general, its applications can be partitioned into four fundamental gatherings as per the way of the image acquisition,

A. Multiview analysis (Different viewpoints):

Images of the same scene are acquired from different viewpoints. The aim is to obtain a larger 2D view or a 3D representation of the scanned scene. Applications like remote sensing for mosaicing of images of the surveyed area are using this technique. In Computer vision the shape recovery (shape from stereo) is obtained by this technique.

B. Multitemporal analysis (Different times):

Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The goal is to evaluate the changes in the scene which appeared between the consecutive images acquisitions.

1) Applications: Applications like Remote sensing, for monitoring of global land usage, landscape plans and in Computer vision, automatic change detection for security monitoring, motion tracking also in Medical imaging, monitoring of the healing therapy, monitoring of the tumor evolution.

C. Multimodal analysis (Different sensors):

Images of the same scene are acquired by different sensors. Goal is to integrate the information obtained from different image acquiring devices and source streams to obtain more complex and detailed scene representation. In remote sensing the fusion of information from sensors with different characteristics like panchromatic images, offering better spatial resolution, color/multispectral images with better spectral resolution, or radar images independent of cloud cover and solar illumination are able to achieve using this technique. In Medical imaging, combination of image acquisition devices recording the anatomical body structure like magnetic resonance image (MRI), ultrasound or CT with sensors monitoring functional and metabolic body activities like positron emission tomography (PET), single photon emission computed tomography (SPECT) or magnetic resonance spectroscopy (MRS) are done.

1) Applications: Results can be applied in radiotherapy and nuclear medicine. Images of a scene and a model of the scene are registered in Scene to model registration. The model can be a computer representation of the scene, for instance maps or digital elevation models (DEM) in GIS, another scene with similar content (another patient), 'average' specimen, etc.

This technique is applied in Remote sensing-Registration of aerial or satellite data into maps or other GIS layers, in Computer vision-Target template matching with real-time images, automatic quality inspection, in Medical imaging the comparison of the patient's image with digital anatomical atlases, specimen classification are performed.Because of the assorted variety of pictures to be enrolled and because of different kinds of debasements it is difficult to plan a general technique relevant to all enlistment assignments. Each strategy should consider not just the accepted kind of geometric twisting between the pictures yet in addition radiometric misshapenings and clamor debasement, required enrollment precision and application-subordinate information attributes.

III. IMAGE REGISTRATION METHODS

The spatial domain of image registration methods mostly consists of the following steps and it was discussed in [1,2].

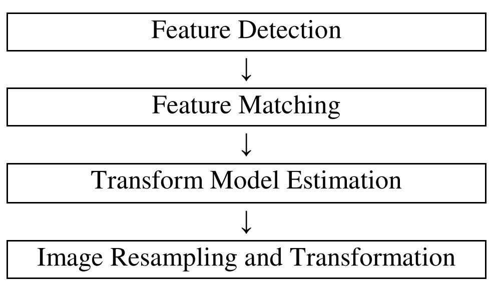

Fig.1. Image registration methods

A. Feature detection:

Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature. See figure(2).

B. Feature matching:

In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Different feature descriptors and comparability measures alongside spatial connections among the highlights are utilized for that reason. See figure(3).

C. Transform model estimation:

The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping capacities are processed by methods for the built up of feature correspondence. See figure(4)

D. Image resampling and transformation:

The sensed image is transformed by means of the mapping functions. Appropriate interpolation technique is used in image values in non-integer coordinates computation. See figure(5).Every registration step has its own problems. To reduce the complexity we have to decide what kind of features is suitable for the given task. The features should not be ordinary it must be distinctive objects, which are frequently spread over the images and are easily perceptible. The physical interpretability of the features is demanded for all process. Basic components must present in the distinguished capabilities in the reference and detected pictures, even in circumstances when the pictures don't cover the very same scene or when there are protest impediments or other surprising changes. The location strategies ought to have great limitation exactness and ought not be delicate to the expected picture degradation. In a perfect case, the calculation ought to have the capacity to identify similar highlights in all projections of the scene paying little heed to the specific picture distortion.

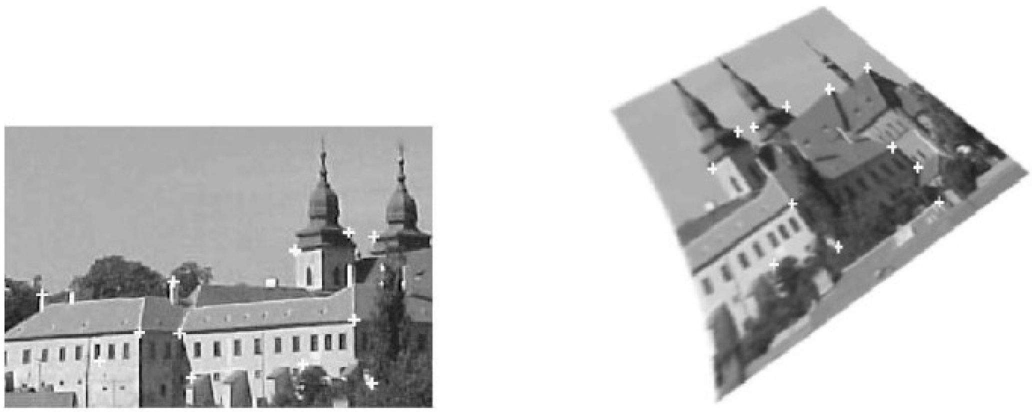

Fig.2. Feature Detection (corners were used as the features in this case)

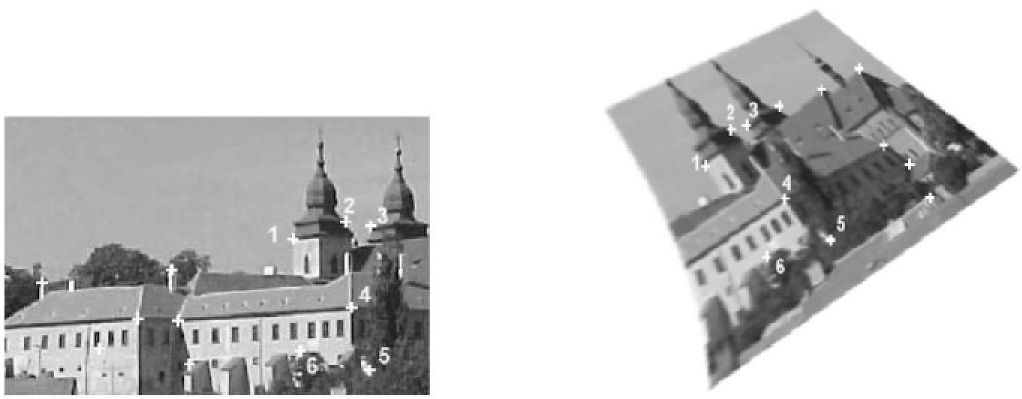

Fig.3. Feature Matching by Invariant Descriptors (the corresponding pairs are marked by numbers)

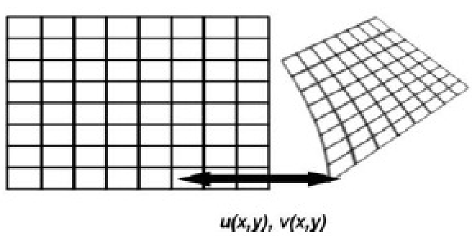

Fig.4. Transform model estimation exploiting the established correspondence.

Fig.5. image resampling and transformation using appropriate interpolation technique

IV. IMAGE CORRELATION METHOD

The historically first survey paper [2] covers mainly the methods based on image correlation. Mono modal images registration are using correlation methods, for comparison of several images of the same object, e.g. to analyze development of the disease. Literature on Cross-correlation of original images or extracted feature images is found in [3-26]. Literature on Fourier domain based cross-correlation, and phase-only correlation is reported in [27-31].

The phase correlation method is based on the Fourier Shift Theorem [32] and was originally proposed for the registration of translated images. It calculates the cross-power spectrum of the sensed and reference images and looks for the location of the peak in its inverse. The method exhibits strong robustness against the correlated and frequency dependent noise and non-uniform, time varying illumination disturbances. The computational time consumption is less which is more significant if the images, which are to be registered, are large. De Castro and Morandi [33] introduced an extension of the phase correlation for additional rotation transform.

V. FOURIER-DOMAIN AND OTHER TRANSFORM-BASED METHODS

Recurrence area techniques give fundamentally a quick option in contrast to processing the connection coefficient closeness measure. A recurrence change changes over an advanced flag, or a picture, to an accumulation of recurrence coefficients that speak to the quality of every recurrence in the first flag. For instance, if the first picture has a substantial number of edges, at that point the recurrence area will have expansive coefficients identified with the customary separation between the edges. Change based enrollment strategies depend on the preface that the data in the changed picture will make the geometric change simpler to recoup. Fourier space strategies depend on Fourier's day of work hypothesis, which expresses that in the event that g(x, y) is a deciphered form of a flag f(x, y) in the spatial ***xy*** space, at that point the relating Fourier transforms G(u, v) and F(u, v) in the recurrence uv area are related by a stage move that can be recouped proficiently. For picture enrollment, the two pictures are changed to the recurrence area by the quick Fourier change (FFT). These changes are then duplicated proficiently in the recurrence area, also, their item is changed back (through the inverse FFT) to the spatial area for recuperation of the interpretation. (The coveted interpretation is found at the area of the reverse change crest.) While the calculation itself is proportionate to that of the relationship coefficient in the spatial space, the computational expense of the abovementioned strategy is $O((n+m)^2 log(n+m))$, instead of the animal power $O(n^2m^2)$.

A Fourier coefficient speaks to a specific recurrence yet does not demonstrate where in the picture highlights with that recurrence happened. Wavelet highlights, then again, give both recurrence furthermore, position data. Subsequently, wavelets are not utilized similarly as Fourier coefficients. As opposed to apply the move hypothesis (as in the Fourier case), wavelets are utilized to deteriorate the picture into higher-recurrence, edge-like highlights, also, bring down recurrence highlights. The higher-recurrence highlights are utilized normally as thick edge highlights for relationship or highlight based coordinating.

A. Geometric Transformations:

Picture enlistment accept an intelligible geometric change between the detected what's more, reference pictures. In the event that adequate information is accessible about the imaging model of the sensor, geometric twists from satellite circle and state of mind varieties, climatic impacts, and topographic alleviation, at that point a physically precise model of the change can be developed, and a suitable calculation for the model can be picked (Huseby *et al*., 2005).

On the off chance that the above data isn't accessible or then again is excessively unpredictable, a rough experimental model can be utilized. A physically exact model is obviously most reasonable for refining a crude remote detecting picture into an orthoimage, that is, a bending free form of the picture that speaks to a perfect projection onto geodetic directions of the ground plane. Completely amended orthoimages are most appropriate for mix into geographic data frameworks and combination with a wide range of geographic information.

All things considered, the changes utilized in the coordinating period of picture enlistment are generally dependent on observational models that offer adequate exactness for the assignment yet are not physically precise. In particular, when a picture enlistment calculation is based on coordinating little picture districts as chips or control focuses, exact models of a basic geometric change as interpretation can be adequately exact even without considering extra components, for example, point of view. Along these lines, numerous picture enlistment calculations utilize exact, low-arrange geometric models over little districts as chips or control focuses, and afterward utilize the control focuses to process more precise, parametric geometric models of higher request. Numerous algorithmic strategies, for example, those dependent on numerical improvement or the Fourier change, are basically intended for the express recuperation of the parameters of a low-arrange demonstrate, for example, interpretation, revolution, and scale. Exact models include:

(1) Rotation, scaling and translation (RST), i.e., transformations with four parameters. The RST model is a useful subset of the affine transformations.
(2) Affine transformation of six parameters.
(3) Projective transformation of eight parameters.
(4) Homography, consists of eight degrees of freedom.
(5) Higher order 2D and 3D polynomial functions.
(6) Rational polynomials.

To estimate the best fit between the two images algorithms like Random Sample Consensus (RANSAC) are used, Sreenith.K.S, S.Senthamilarasu[34] have discussed biometric authentication technique using sclera vein image.

B. Radiometric Transformations and Resampling

Under the right geometric change, two relating picture focuses ought to have related force esteems. In the event that we accept that the relating picture focuses speak to a similar ground include, at that point the radiometric readings of that highlight ought to have some consistency between two detecting occasions. That consistency or on the other hand relationship bewilders various components, for instance, the radiometric reactions of the two sensors, the season of day and other ecological components, the point of view, the specular reaction of the ground highlight, and so on. This is further jumbled by multiband sensors, so in enlisting two pictures we might relate two phantom groups which might possibly cover. On the off chance that we can represent all these factors, we can assemble a radiometric model (or capacity g) that maps forces in one picture to another, and utilize this model in structuring an enlistment calculation. Be that as it may, few picture enrollment calculations utilize unequivocal radiometric connections amid the coordinating procedure. This is on the grounds that the relationship might be hard to adjust, the calculation might be utilized on numerous sensors (so a solitary relationship is not helpful or proper), and the jumbling ecological variables may overpower the relationship. Rather, most enrollment calculations base their closeness measures on general suspicions made about the relationship, either unequivocally or verifiably. Along these lines, picking the proper suppositions is imperative in calculation structure and determination.
(1) In identity relationship the image intensity is assumed to be invariant. This assumption is explicit in methods based on similarity measures that sum directly the square of absolute values of intensity differences.
(2) Affine relationship, i.e., assuming that the intensities differ by a linear gain and bias. This assumption is implicit in methods based on the correlation coefficient or least squares minimization.
(3) Functional relationship assumes that the intensities differ by a general function. This assumption is implicit in a few measures, including the correlation and Woods measures.
(4) Statistical relationship, i.e., assuming that while individual corresponding points may have differing intensities, in local neighborhoods they are drawn from the same statistical distribution.

VI. CONCLUSION

Picture enlistment is a standout amongst the most vital undertakings when coordinating and examining data from different sources. It is a key stage in picture combination, change location, super-goals imaging, and in building picture data frameworks, among others. This paper gives a study of the traditional and a la mode enrollment strategies, ordering them as indicated by their inclination and in addition as per the four noteworthy enlistment steps. Despite the fact that a considerable measure of work has been done, programmed picture enlistment still remains an open issue. Enlistment of pictures with complex nonlinear also, nearby contortions, multimodal enrollment, and enlistment of N-D pictures have a place with the most difficult assignments right now. Later on, the possibility of an extreme enrollment technique, ready to perceive the kind of given errand and to choose by itself about the most fitting arrangement, can spur the improvement of master frameworks. They will be founded on the blend of different methodologies, searching for accord of specific outcomes.

REFERENCES

[1] Barbara Zitova, Jan Flusser, "Image registration methods: a survey", Image and Vision Computing, 21 (2003) 977–1000.

[2] B.K. Ghaffary, A.A. Sawchuk, "A survey of new techniques for imageregistration and mapping", Proceedings of the SPIE: Applications of Digital Image Processin, 432 (1983) 222–239.

[3] F. Maes, A. Collignon, D. Vandermeulen, G. Marchal, and Suetens, "Multimodality image registration by maximization of mutual information," IEEE Transactions on Medical Imaging, vol. 16, no. 2, (1997), 187–198

[4] S. Sanjay-Gopal, H. P. Chan, T. Wilson, M. Helvie, N. Petrick and B. Sahiner, "A regional registration technique for automated interval change analysis of breast lesions on mammograms," Medical Physics, vol. 26, no. 12, (1999), 2669–2679

[5] L. Junck, J. G. Moen, G. D. Hutchins, M. B. Brown, and D. E. Kuhl, "Correlation methods for the centering, rotation, and alignment of functional brain images", Journal of nuclear medicine, 31,(1990), 1220–1276

[5] S. L. Bacharach, M. A. Douglas, R. E. Carson, P. J. Kalkowski, N. M. T. Freedman, P. Perrone-Filardi and R.O.Bonow, "Three-dimensional registration of cardiac positron emission tomography attenuation scans", Journal of nuclear medicine, 34(2), (1993), 311–321

[6] V. Bettinardi, M. C. Gilardi, G. Lucignani, C. Landoni, G. Rizzo, G. Striano and F. Fazio, " A procedure for patient repositioning and compensation for misalignment between transmission and emission data in PET heart studies", Journal of nuclear medicine, 34, (1993), 137–142.

[7] L. Lemieux, R. Jagoe, D. R. Fish, N. D. Kitchen and D. G. T. Thomas, " A patient-to-computed tomography image registration method based on digitally reconstructed radiographs", Medical physics 21(11) , (1994), 1749–1760

[8] J. B. A. Maintz, P. A. van den Elsen, and M. A. Viergever, "Evaluation of ridge seeking operators for multimodality medical image matching., IEEE Transactions on pattern analysis and machine intelligence, 18(4), (1996), 353–365

[9] P. Hua and I. Fram, "Feature-based image registration for digital subtraction angiography", M. H. Loew, editor, Medical imaging: image processing", vol 1898, Bellingham, WA, (1993) SPIE Press, 24-31

[10] B. Munch and Ruegsegger, "3-D repositioning and differential images of volumetric CT measurements", IEEE Transactions on medical imaging, 12(3), (1993), 509–514

[11] P. A. van den Elsen and M. A. Viergever "Automated CT and MR brain image registration using geometrical feature correlation", Proceedings of the Nuclear science symposium and medical imaging conference, IEEE, (1993), 1827– 1830.

[12] J. B. A. Maintz, P. A. van den Elsen, and M. A. Viergever, "Using geometrical features to match CT and MR brain images", Medical imaging, analysis of multimodality 2D/3D images, volume 19 of Studies in Health, Technology and Informatics, IOS Press, Amsterdam, (1994), 43-52

[13] P. A. van den Elsen, "Retrospective fusion of CT and MR brain images using mathematical operators", AAAI symposium on medical applications of computer vision, (1994), 30– 33

[14] P. A. van den Elsen, E. J. D. Pol, T. S. Sumanaweera, P.F. Hemler, S. Napel, and J. Adler., "Grey value correlation techniques used for automatic matching of CT and MR brain and spine images", Visualization in Biomedical Computing, volume 2359 of Proc, SPIE Press, Bellingham, WA, (1994), 227-237.

[15] P. A. Van den Elsen, J. B. A. Maintz, E.J.D. Pol and M. A. Viergever, "Automatic registration of CT and MR brain images using correlation of geometrical features", IEEE Transactions on medical images, 14(2), (1995), 384–398

[16] J. B. A. Maintz, P. A. van den Elsen, and M. A. Viergever, "Comparison of edge-based and ridge-based registration of CT and MR brain images", Medical image analysis, 1(2), (1996), 151-161

[17] T. Radcliffe, R. Rajapakshe, and S. Shalev. "Pseudocorrelation: a fast, robust, absolute, grey-level image alignment algorithm", Medical physics, 21(6), (1994), 761–769

[18] A. V. Cideciyan, "Registration of ocular fundus images", IEEE Engineering in medicine and biology, 14(1), (1995), 52–58

[19] D. L. Collins, A. C. Evans, C. Holmes and T. M. Peters, "Automatic 3D segmentation of neuro-anatomical structures from MRI", Information processing in medical imaging, Kluwer, (1995), 139-152

[20] C. Studholme, D. L. G. Hill and D. J. Hawkes. "Multi resolution voxel similarity measures for MR-PET registration", Information Processing in Medical Imaging, Kluwer, (1995), 287-298

[21] T. Meera Devi and Mrs. M. Madhumalini 'Glaucoma-a Survey on Prevalence', 2017 in Middle-East Journal of Scientific Research, ISSN: 1990 - 9223, Volume No.25, Issue 3, pp 511-517.

[22] L. Gottesfeld Brown and T. E. Boult., "Registration of planar film radiographs with computed tomography", Mathematical methods in biomedical image analysis, Los Alamitos, (1996), IEEE computer society press, 42-51

[23] D. H. Hristov and B. G. Fallone, "A grey-level alignment algorithm for registration of portal images and digitally reconstructed radiographs", Medical physics, 23(1), (1996), 75-84

[24] J. L. R. Andersson, A. Sundin, and S. Valind, "A method for coregistration of PET and MR brain images", Journal of nuclear medicine, 36, (1995), 1307–1315

[25] J. L. R. Andersson, "A rapid and accurate method to realign PET scans utilizing image edge information", Journal of nuclear medicine, 36, (1995), 657–669

[26] P. K. Banerjee and A. W. Toga, "Image alignment by integrated rotational and translational transformation matrix", Physics in medicine and biology, 39, (1994), 1969–1988

[27] E. de Castro and C. Morandi, "Registration of translated and rotated images using finite Fourier transforms", IEEE Transactions on pattern analysis and machine intelligence, 5, (1987), 700–703

[28] V. Leclerc and C. Benchimol, "Automatic elastic registration of DSA mages", Computer assisted radiology, (1987), 719– 723

[29] Q Chen, "Image registration and its applications in medical imaging" PhD thesis, Vrije University, Brussels, Belgium, (1993)

[30] H. Shekarforoush, M. Berthod and J. Zerubia, "Subpixel image registration by estimating the polyphase decomposition of cross power spectrum", Computer vision and pattern recognition, Los Alamitos, CA, (1996), IEEE CS, 532– 537

[31] J. Wang, L. E. Reinstein, J. Hanley, and A. G. Meek, "Investigation of a phase-only correlation technique for anatomical alignment of portal images in radiation therapy", Physics in medicine and biology, 41, (1996), 1045–1058

[32] R.N. Bracewell, The Fourier ransform and Its Applications, McGraw-Hill, New York, 1965.

[33] E.D. Castro, C. Morandi, "Registration of translated and rotated images using finite Fourier transform", IEEE Transactions on Pattern Analysis and Machine Intelligence 9 (1987) 700–703.

[34] Sreenith.K.S, S.Senthamilarasu, "A Neural approach for sclera vein recognition", International Journal of Advanced Research in Computer and Communication Engineering, Volume 4, Issue 4, April 2015, pp 147-151.