

Numerical accuracy of the algorithms can be evaluated by comparing the results of the attached Matlab code named “Main Example”, Note that workpiece refinement can be changed for more results to prove the efficiency and robustness of the code with discretization sensitivity of the orthogonal cutting process.

5. Results and Discussion

Contact Detection is a nonlinear process that takes place at every simulation step to detect contact pairs. Therefore, a slight difference in algorithms runtime is more apparent in the overall performance of the FEM simulation especially for the complex geometry and multiple contacts zone that have expensive computationally cost. Fig 08 shows the results of the first test, a large difference in computational time between the two algorithms, appears clearly when increasing nodes. The average time of the bucket sort method is 0.02 Sec while the average time for All-to-All method is 0.64 Sec and this could be explained by the fact that the BS method only performs the operation for the nodes close to the collision zone i.e. nodes situated at the bounding boxes overlap and thereby it decreases the computational time compared to the exhaustive search (All-to-All method) where it performs the operations of the whole nodes against all existing segments and this process can be computationally expensive.

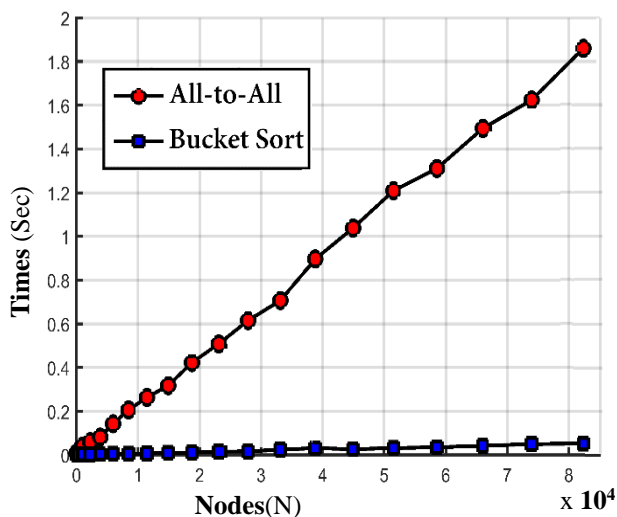


Fig. 8: Runtime of BS and All-to-All Methods According to Increasing Nodes

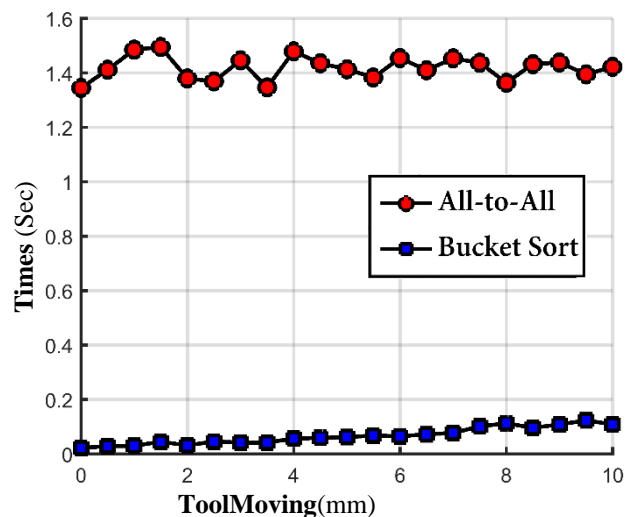


Fig. 9: Runtime of BS and All-to-All Methods According to Tool Moving

Fig 09 shows the second test, Tool progress or the increase of contact pairs has no effect on the runtime of the All-to-All method because workpiece nodes are fixed and the process performs on all nodes, regardless of whether there is a contact or not, while the presence of contact nodes increase the runtime for the BS algorithm because the process depends mainly on the intersection nodes situated on the overlap Bounding Boxes and the contact between the cutting tool segments and workpiece nodes increase the intersection nodes i.e. contact pairs that will be subject to study and thereby increase the time required to extract the contact pairs, but All-to-All method remains incomparable to the runtime required for BS method. Orthogonal cutting process needs a fine mesh i.e. large contact pairs number at the cutting zone to accurately capture the contact forces. Hence, there are no significant differences in static simulation that require few simulation steps between the two search algorithms. These differences begin to appear in dynamic simulation or dynamic refinement in which extremely large simulations should be expected. Therefore to minimize the computational costs neighbour search algorithms e.g. Bucket sort algorithm will be an ideal choice.

6. Conclusion

In this research paper, one of the modern methods used in contact detection was studied compared to a classic method used for simple models [15], the research paper proved that the methods depend on neighbourhood identification (BS method) reduce runtime in a feasible and effective way, especially since the contact problems are based on the iterative and incremental process that could be computationally expensive in particular for complex and irregular geometries, large deformation and large rotation analysis and various contact concept in the same analysis. Thereby this prompts research towards finding new strategies to minimize the computational cost, simplify the contact problem and agree with the analytical and experimental results.

7. References

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