이동체의 실시간 위치추적을 위한 PID제어 이동체 Spatio-Temporal 모델 알고리즘

왕지* ·선양* ·이규호*

*인제대학교

PID-controlled Moving Objects Spatio-Temporal Model Algorithm for Identifying the Location of a Mobile Object in Real-time

Zhi Wang* ·Sun Ying* ·Kyou-Ho Lee*

*Inje University

E-mail : wangzhi86813@163.com

요 약

삼각측량법은 전형적인 위치인식 방법으로, 최소 세 곳의 위치정보가 기인지된 기준점을 필요로 한다. 어떤 경우에는 통신도달 범위를 벗어날 수 있는 이유로 목표 노드로 부터 세 개의 기준 스테이션에 항상 통신 도달성이 제공되는 것은 아니다. 본 논문은 목표 노드가 모든 세 기준 스테이션을 접근할 수 없는 경우에도 실시간으로 이동 목표 노드의 위치를 추정할 수 있는 방법을 제시한다. 제시된 방법은 PID제어이동체 Spatio-Temporal 모델 알고리즘에 기반을 두고 있다. 이 방법은 이동체의 진행방향을 추정할 수 있고, 이러한 추정방향과 목표노드의 기 확인된 위치정보를 함께 활용하여 이동체의 정확한 위치를 판단할 수 있다.

ABSTRACT

Triangulation is a typical method to locate or identify the location, which requires inherently at least three pre-recognized reference points. In some cases, owing to out of reachability to communication facility the target node can not reachable always to three base stations. This paper presents a predictive method, which can estimate the location of the moving target node in real time even though the target could not get in touch with all three base stations. The method is based on the PID-controlled Moving Objects Spatio-Temporal Model Algorithm. This can predict the moving direction of the moving target, and then combine with the past target position information to judge accurately the location.

키워드

Real Time Locating, Prediction, Triangulation, Spatio-Temporal Model Algorithm

Ⅰ. INTRODUCTION

To pursue the location of users in real time is important and then essentially required for the u-health service that users could occasionally be in the situation beyond self-regulation. Triangulation is a generally accepted method to locate or identify the location, which requires inherently at least three pre-recognized reference points[1]. This includes measuring distances between at least three reference points and the target node. Such various teninologies as ROA(RSSI of Arrival), AOA(Angle of Arrival), TOA(Time of Arrival), TDOA(Time Difference of Arrival), TWR(Two Way Ranging), SDS-TWR(Symmetrical Double Sided Two Way Ranging), etc. were studied for measuring distances[2]~[5].

Users, in some cases, become out of reachability in any such reasons as out of propagation ranges, fault of a communication counterpart, non-existence of possible communication facility, etc.[6]~[8] Such cases could not make the target node always reachable to three base stations. In such cases, we can use some prediction algorithm and refer to the orientation of the target in last few moments to predict the position.

This paper presents a predictive method, which can estimate the location of the moving target node in real time even though the target could not get in touch with all three base stations. The method is based on the PID-controlled Moving Objects Spatio-Temporal Model Algorithm. We also build simulators to verify the proposed method reasonable.

Ⅱ. Locating by Triangulation

Figure 1 shows to preciously identify a node A by the triangulation method. R1, R2 and R3 in the figure are three resident coordinates used for trilateration, and d1, d2 and d3 are distances between three resident coordinates R1, R2 and R3 and the target node, respectively, which could be measured by any ranging method described in Section I.

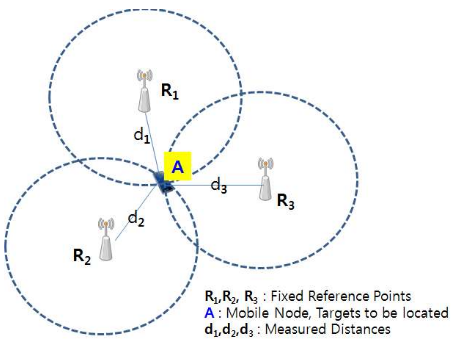

Fig. 1. Location identifying by triangulation

Let us consider the case that a target node is reachable to only two resident coordinates, as shown in Figure 2, in any such reasons as out of propagation ranges, fault of a communication counterpart, non-existence of possible communication facility, hardness of constructing resident coordinates, etc. In Figure 2, there are two resident coordinates, R1 and R2, so that it is insufficient for trilateration. With two information, d1 and d2 which are distances of the target node from R1 and R2 respectively, it comes to know that the location of A is either A1 or A2.

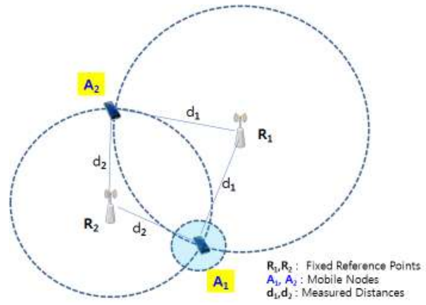

Fig. 2. Identifying by two resident coordinates

It can acquires location flow information of A from past location data of A, i.e. A(t-1), A(t-2), ⋯ A(t-n). Applying this information to A1 and A2, the current location of A is easily to decide.

Such a method is also applicable to the case that only one resident coordinator is available for locating. The server system should maintain location flow information and use it to identify the new location.

Ⅲ. Proposed Algorithm

A. System Model

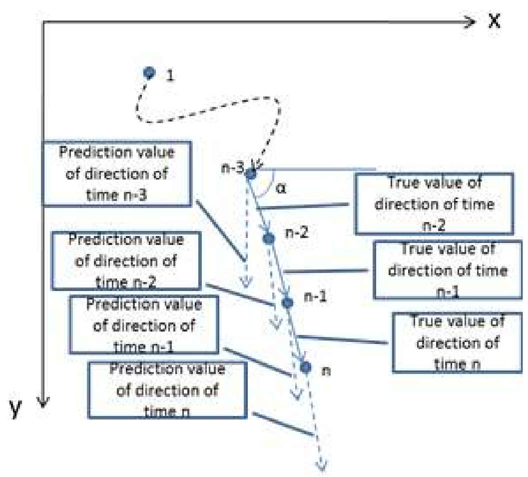

Fig. 3. Movement direction angle

As shown in figure 5, in x-y coordinate, we make the angle between the measured orientation of the target and the x coordinate as the movement direction angle. For the current moment we introduce the predicted orientation of last moment and the measured orientation of current moment and the predicted orientation of current moment as three parameters.

B. Proposed Algorithm

In a moving-average model of Moving Object Spatio-Temporal (MOST), $|\vec{v}| = \frac{1}{p}\sum_{i-1}^{p} v_{n-1}$[9]. So *Prediction Value* = *True Value*. True Value is a true value of direction of time n, while Prediction Value is a prediction value of direction of time n. There is no mechanism to reduce an error between True Value and Prediction Value. So we want to work out a mechanism to minimize the error. Since the PID controller is generally acceptable for optimization in automatic control systems, we choose it as a mechanism to minimize the error.

The proposed PID-controlled Moving Objects Spatio-Temporal Model Algorithm can be considered as two parts: controlling part and controlled part. The controlling part is a PID controller. The controlled part is a Moving Objects Spatio-Temporal model algorithm. The input is True Value of direction of time n, and the output is Prediction Value of direction of time n, supposing the current time is Time n. The feedback is Prediction Value of the direction of the time n-1. Setpoint is the expectation of the error between Prediction Value of the direction of the time n-1 and True Value of the direction of the time n. Obviously, setpoint is 0. A is the error between Prediction Value of the direction of the time n-1 and True value of the direction of the time n. The error is a difference between A and setpoint of the time n.

PID Value=P Value + I Value + D Value[10]

PID Value =

$K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt}$, where e(t) is the error. Kp, Ki, and Kd are the coefficient of P value, I value, and D value, respectively.

The whole expression is Prediction value(t) = True Value(t) PID VALUE(t), PID VALUE = $K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt}$, e(t)= True Value(t) - Prediction value(t-1).

In this paper, we choose Kp=0.1, Ki=0.005, and Kd=0.

Ⅳ. Simulation Result

Simulation results compare the True direct (TRUE_A) with five predictive directions of every point of Target A. Those predictive directions were calculated by the Recursive Least Squares algorithm (Least_A), the Kalman Filter estimation algorithm (Kalman_A), the Stochastic Approximation algorithm (Stochasic_A), the Moving Object Spatio-Temporal Model Algorithm (Model_A), and the proposed PID-controlled MOST Model algorithm (Testalgor_A).

Figure 4 shows the true direction and five predictive directions of every point of Target A in each step.

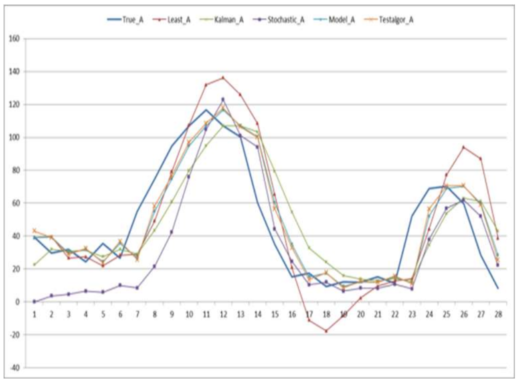

Figure 4. Simulation results: directions

Figure 5 shows the difference between the true direction and five predictive directions of every point of Target A in each step.

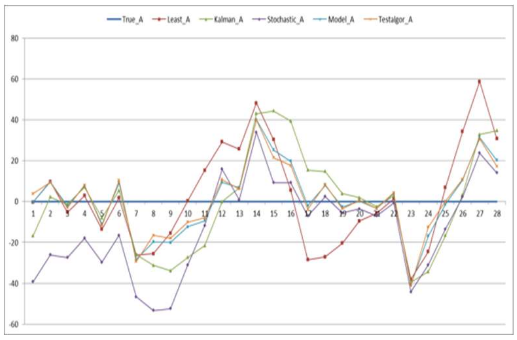

Figure 5. Simulation results: differences

Figure 6 shows cumulative differences between the true direction and five predictive directions of every point of Target A in each step.

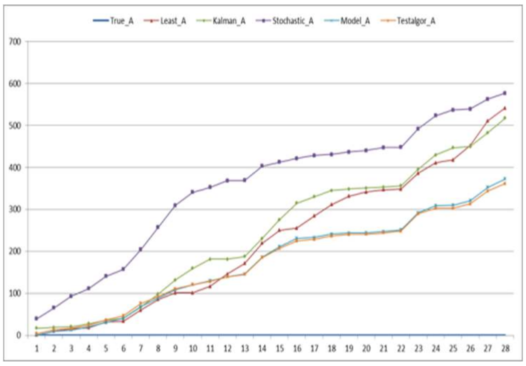

Figure 6. Simulation results: cumulative difference

Ⅴ. Conclusion

This paper presents a predictive method, which can estimate the location of the moving target node in real time even though the target could not get in touch with all three base stations. We proposed a PID-controlled Moving Objects Spatio-Temporal Model algorithm and refer to the orientation of the target in last few moments to predict the position. The method can predict the moving direction of the moving target, and then combine with the past target position information to judge accurately the location. Simulation results can verify the proposed algorithm reasonable for predicitng in real time the location of the moving target node which is not reachable to all three base stations.

Although using PID controller makes the result closed to the true value, the result is similar to the original MOST algorithm. The further work is modifying parameters of the PID controller or selecting a better control in order to get better result.

REFERENCES

[1] Grimm, R. Edelhausser, T Kokai, G., “An Efficient Configuration Method for Real Time Locating Systems,” 2nd International Conf. on Logistics and Industrial Informatics, pp.1-6, 2009.

[2] Yi Jiang, et al., “An asymmetric double sided two-way ranging for crystal offset,” In Proceedings of the Int. Symposium on signals, systems and Electronics, IEEE, pp. 525-528, 2007.

[3] Y. Jiang, et al., “An Asymmetric Double Sided Two-Way Ranging for Crystal Offset,” International Symposium on Signals, Systems and Electronics (ISSSE’07), pp. 525~528, July 2007.

[4] H. Cho, et al., “Real Time Locating System for Wireless Network using IEEE 802.25.4 Radio,” Sensor, Mesh and Ad Hoc Communications and Networks(SECON), pp. 578 580, June 2008.

[5] Jeffrey Hightower, et al., “A Survey and Taxonomy of Location Systems for Ubiquitous Computing,” IEEE Computer, vol. 34, no. 8, pp. 57-66, August 2001.

[6] Bin Ko, et al., “Data Transport Performance in Various and Interworked u-Health Service Networks,” Proceedings of KICS Autumn Conference 2008, Seoul, Nov. 2008(In Korean).

[7] Kyou H. Lee, et al., “A Study on Improving Performance of the Network Transport by Interworking Different Protocols,” Journal of Maritime Information and Communication Sciences (KIMICS), Vol.13, No.1, Jan. 2008 (InKorean).

[8] Kyou H. Lee, “Network Accessibility and Data Transport Performance of Interworking Mobile Ad Hoc Networks,” International Journal of Maritime Information and Communication Sciences (KIMICS), Vol.7, No.1, December 2009.

[9] He Yunbin, Fan Shoudem, Hao Zhongxiao “Whole Trajectory Modeling of Moving Objects Based on MOST Model” Computer Engineering, Vol. 34 No. 16, August 2008

[10] PID controller http://en.wikipedia.org/wiki/PID_controller